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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Page 127, May 21.

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See page 17, May 21. 8305

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See Advertisement page 26. 8187

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Patent
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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Archts. and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4832

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&c. &c. 7726

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See half-page Advertisement page 99, May 14.

See Advt. Page 134, May 21.
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TENDERS.

AUCKLAND HARBOUR BOARD.
NEW ZEALAND.

Tenders are Invited for the

SUPPLY of THREE steel dumb HOPPER BARGES, 3/400 cubic yards capacity.
Specifications can be obtained on payment of a deposit of two guineas at the office of the Board's Agents, Messrs. W. & A. MCARTHUR, LTD., 18/19, Silk Street, Cripplegate, London, E.C. 2.
Tenders to reach Messrs. W. & A. MCARTHUR, LTD., not later than 31st July, 1920. G 776

LONDON COUNTY COUNCIL.

The Council invites

Tenders for the Supply of

4000 DRIVING WHEEL TYRES, and 3500 TRAILING WHEEL TYRES for Electric Tramways.
The form of Tender may be obtained from the General Manager, London County Council Tramways, 23, Belvedere Road, Lambeth, S.E. 1.
No Tender received at the County Hall, Spring Gardens, S.W., after 12 noon on Tuesday, 15th June, 1920, will be considered.
The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council.
G 737

LONDON COUNTY COUNCIL.

Tenders are Invited for the

roadwork and platelaying for the construction of tramways in Well Street and Lauriston Road, Hackney, and the reconstruction of tramways in Church Crescent, Grove Road, Burdett Road, and West India Dock Road. The length of track is about 5½ miles of single line. Certain paving works will also be included. The Contractor will be required to use the rails with their fastenings and the special work for the various crossovers, &c., provided by the Council.
Forms of Tender and all necessary documents may be obtained from the Council's CHIEF ENGINEER, MR. G. W. HUMPHREYS, O.B.E., the County Hall, Spring Gardens, S.W.1, upon payment to the Cashier of the Council, of £5. This amount will be returned only if a *bona fide* Tender is submitted. The particulars of the work and the conditions of contract may be obtained at the County Hall, before payment of this fee.
Tenders must be on the Official Forms. No Tender received after Four p.m., on Monday, 21st June, 1920, will be considered. The Council does does not bind itself to accept any Tender. G 770

JAMES BIRD,
Clerk of the London County Council.

G. R.

MINISTRY OF MUNITIONS.

BY DIRECTION OF THE DISPOSAL BOARD (PLANT AND MACHINERY SECTION).

FOR SALE BY PUBLIC TENDER
OIL FUEL INSTALLATION.

Tenders are Invited for the

following:—
ADMIRALTY OIL FUEL INSTALLATION, erected in 1916, on land adjacent to Alexandra Dock, Hull, known as Hedon Road Reservation, consisting of STEEL TANK, 80 ft. dia. by 30 ft. deep, with C.I. pipe lines, from 6 in. to 15 in. dia., running under or along the adjacent land and jetty. The PUMP HOUSE 31 ft. 6 in. by 23 ft. 6 in. contains 2 Hayward Tyler Pumps, each direct coupled to motor.
The Hull Corporation are prepared to negotiate with a reputable purchaser for a lease of the land on which part of this installation stands (including Tank and Pump House) for a term of 50 years with option of renewal for a further 25 years, but the pipe lines which run along jetty will require to be removed.
Drawings and Specifications can be seen, permits to view and Tender Forms obtained from the CONTROLLER, Plant and Machinery Section of Disposal Board (D.B.1.a.), Charing Cross Embankment Buildings, London, W.C. 2.
Tenders close on June 14th, 1920.
NOTE.—For particulars of other Government Property for Sale, see *Surplus*, price 3d., at all bookstalls; or by quarterly subscription of 2s. post free in the United Kingdom, payable in advance to the Director of Publicity, Ministry of Munitions, Whitehall Place, London, S.W. 1. G 760

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED,
are prepared to receive

Tenders for the Supply of:—

BRIDGEWORK, 25–64 ft., Plate Girder Spans (700½ tons).
Specifications and forms of Tender may be obtained at the Company's Offices, 91, York Street, Westminster, S.W. 1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Bridgework," must be left with the undersigned not later than Two p.m. on Tuesday, the 8th June, 1920.
A charge, which will not be returned, will be made of 20s. for each copy of the Specification. Copies of the drawings may be obtained at the office of ROBERT WHITE, Esq., M.Inst.C.E., Consulting Engineer to the Company, 3, Victoria Street, Westminster, S.W.

By Order,
W. B. REYNOLDS,
for Managing Director.

91, York Street,
Westminster, S.W. 1.
21st May, 1920. G 741

The North Eastern Railway

COMPANY have the following second-hand PLANT for DISPOSAL at their Hydraulic Power Station at West Hartlepool:—
A STEAM-DRIVEN HYDRAULIC PUMPING ENGINE, suitable for 750 lbs. per sq. inch hydraulic pressure and 110 lbs. per sq. inch steam pressure.
The Engine is fitted with two cylinders each 16 in. diameter by 24 in. stroke, direct coupled to two "Armstrong" type Hydraulic Pressure Pumps, having rams 4 in. dia., and pistons 5½ in. dia.
The Engine has two large cast iron fly wheels, one on each side of the bedplate, and the steam cylinders are in the centre between the crank-shaft and the pumps, the whole of the machine being mounted on a massive cast iron bedplate. The Engine is complete with suction valves, governor and steam stop valve, the suction pipes being 5 in. dia., and the delivery pipes and steam pipes 4 in. dia.
The Railway Company will disconnect the pipes at the first joint below the engine house floor level, and all piping and valves from this point to the engine will be taken over by the purchaser. The Engine is in running order.
5 Ton HYDRAULIC CRANE, made by Messrs. Tannett, Walker & Co., having a wheel base of 13 ft. 2½ in., gauge 13 ft. 5 in., height from centre of jib head sheave to rail level 53 ft., and suitable for a hydraulic working pressure of 750 lbs. per sq. inch. The Crane is in fair condition, but is partially dismantled, and some of the stays are broken. The Crane is lying near No. 2 Sheer Legs, at West Hartlepool Dock, and is offered on the condition that it is dismantled where it stands and removed by purchaser at own expense.
Both the above may be seen on application to Mr. G. MACALPINE, Mechanical Engineer, Hydraulic Power Station, Middleton Road, West Hartlepool.
Forms of Tender may be obtained on application to Mr. R. H. CLARK, Stores Superintendent, North Eastern Railway, Gateshead, and must be returned addressed to him by 9.30 a.m., on Tuesday, 8th June. G 716

CONTRACTS, &c.

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND)

CONTRACTS, 1920.

The Directors of the Great Southern and Western Railway Company are prepared to receive alternative

Tenders for the Supply of

the undermentioned STORES for both Six and Three Months commencing 1st July, 1920:—

	No. of Form.
Baskets	10
Bolts, Nuts and Rivets	15
Brooms and Brushes	13
Brass Fittings for Carriages	18
Do. do. for Lamps	18A
Do. do. for Water	36A
Do. do. for Gas ...	36B
Bunting	7B
Canvas and Sacks ...	6
Carriage Laces ...	7A
Castings, Mall. Iron	11
Cement	34
Cloth Carr. ...	7C
Clothing, Oil... ...	9B
Do. I.R. proofed	9B
Coach Screws and Washers	15
Colours	2
Corks	39
Cotton Waste ...	5A
Crucibles	41
Drysalteries	3
Emery and Glass Cloth, etc.	28
Files and Tool Steel	20
Fire Bricks and Clay	33
Foundry Requisites	42
Galv. Sheets, Buckets, etc.	23
Grates, Stoves and Fenders	24
Grindstones	28
Glass, Sheet and Plate... ...	37A
Glass and China Sundries	27B
Hardware (Sundry)...	17
Incandescent Fittings for Gas	26C
India Rubber Goods	9A
Implements, Sundry	21
Iron Tubes and Fittings...	29
Iron and Steel Wire	30A
Leather	12
Linen	8
Locks and Keys ...	19
Mats, Fibre	10
Morocco	7B
Nails	31
Plumbago	41
Rain Water Pipes and Gutters	35
Ropes, Twine, and Flax	4
Sewer Pipes, Plaster, etc.	32
Shovels, Spades, etc.	21A
Soft Goods	9
Sponge Cloths ...	8
Signal Wire Pulleys	11
Screws and Split Pins	14
Tin Plates	22
Varnishes	1
Waste	5A
Waterproof Clothing	9B
Wicks	5
Wire, Fence and Signal	30A
Wirework	30B

Forms of Tender can be obtained on *PAYMENT* of 6d. each from the STORES SUPERINTENDENT, GENERAL STORES DEPARTMENT, G.S. & W.R., INCHICORE, DUBLIN. Applications for forms by Post must be accompanied by Postal Order. Stamps cannot be accepted. All enquiries for information should be also directed to the Stores Superintendent.
Patterns may be inspected at the General Stores Department on and after the 28th inst., between the hours of Ten a.m. and Four p.m. (except on Saturdays).
Tenders must be enclosed in the special envelope supplied for the purpose with each Schedule, and must be posted so as to be with the undersigned before Ten a.m., on Wednesday, 9th June, 1920.
The Directors will not consider any Tender unless it is furnished on the Company's Form, and do not bind themselves to accept the lowest or any Tender.

By Order,
(Signed) ROBERT CRAWFORD, Secretary.
Kingsbridge Terminus, Dublin,
May, 1920. G 735

AUCKLAND HARBOUR BOARD.
NEW ZEALAND.

Tenders are Invited for the

SUPPLY of ONE Two Ton TRUCK CRANE.
Specifications can be obtained on payment of a deposit of Two Guineas, at the office of the Board's Agents, Messrs. W. & A. MCARTHUR, LTD., 18/19, Silk Street, Cripplegate, London, E.C. 2.
Tenders to reach Messrs. W. & A. MCARTHUR, LTD., not later than 31st July, 1920. G 775

BOROUGH OF CREWE.

BOROUGH ENGINEER AND SURVEYOR'S DEPARTMENT.

The Corporation are prepared to receive

Offers for a Petrol Engine,

which has been removed from a Mark 4 Tank.
The Engine may be inspected on application to the undersigned.
Offers to reach the undersigned by Nine a.m., on Monday, the 14th June, 1920.
L. ST. G. WILKINSON, M.Sc., A.M.Inst.C.E.,
Borough Engineer and Surveyor.
Municipal Buildings,
Crewe.
26th May, 1920. G 792

BOMBAY, BARODA AND CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to noon on Friday, 11th June (this date will be strictly adhered to)

Tenders for the Supply of:—

1. Steel Material.
2. Bearing Plates.

Tenders must be made on Forms, copies of which, with Specification, can be obtained at these offices on payment of 20s. each (which will not be returned).
The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices:—
110, Bishopsgate,
London, E.C. 2.
N.B.—On and after the 10th June, the Company's offices will be White Mansion, 91, York St., Westminster, S.W. 1. G 758

LIVERPOOL CORPORATION ELECTRIC SUPPLY DEPARTMENT.

Plant for Sale.

Two 2000 K.W. Double Flow Westinghouse Parsons TURBO ALTERNATORS with Condensers, Air Pumps and Gwynne Circulating Pumps. Steam pressure 180 lbs. per sq. in. Speed, 1500 R.P.M.
Each generator capable of giving three phase current at 6000 to 6600 volts between adjacent conductors at 50 per second separate excitation at 460 to 580 volts.
Offers for the above plant, which must be removed to make room for machines of larger capacity, to be addressed to the Town Clerk so as to be received by him not later than the first postal delivery on June 14th, 1920, endorsed "Tender for Turbo Generator."
The Corporation do not bind themselves to accept the highest or any Tender.
The Plant may be seen running at the Power Station by appointment, and full particulars and Forms of Tender may be obtained on application to the City Electrical Engineer, 24, Hatton Garden, Liverpool.

EDWARD R. PICKMERE,
Municipal Buildings, Town Clerk.
Dale Street,
Liverpool. G 762

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of the

following stores, namely:—

	Specification Fees.
1. Laminated Springs, &c.	£1
2. Plate Glass, &c.	10/-
3. India Rubber Hosepipes, Sheets, &c.	7/6
4. Galvanised corrugated Sheets, &c.	10/-
5. Spring Steel.	10/-
6. Moist Black Paint.	10/-
7. Leather Hides, &c.	10/-

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.
The fee should accompany any application by post.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Laminated Springs, &c." or as the case may be, not later than Eleven o'clock a.m., on Tuesday, 8th June, 1920.
The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 26th May, 1920. G 780

APPOINTMENTS OPEN.

HARRIS INSTITUTE, PRESTON.

Wanted a full time Assistant

TEACHER in Mechanical Engineering to commence duties in September. Applications before 16th June stating age, qualifications, and teaching experience with salary required to the Principal. G 691

THE TECHNICAL COLLEGE, LOUGHBOROUGH.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc., A.M.I.C.E., D.I.C., Principal.

Applications are Invited for

the POSITION of LECTURER in the Department of Automobile Engineering.
Applicants must possess a University Degree or its equivalent. Previous teaching experience in Automobile Engineering desirable, but not essential.
Commencing salary, £350 per annum. G 725

UNIVERSITY OF MANCHESTER.

The Council is about to make

Two Appointments in the

DEPARTMENT of ENGINEERING. Each post will be that of Assistant Lecturer and Demonstrator in Drawing.
The appointments are for three years, and the duties commence in October next.
Applications should be sent, not later than 21st June, to the SECRETARY to the Senate, from whom further particulars may be obtained. G 738

ASSISTANT MASTER, H.M. DOCKYARD SCHOOLS.

Applications are Invited

for the POST of JUNIOR ASSISTANT MASTER in the above schools.
Candidates should possess a University Degree in Honours in Science or Engineering, or have equivalent qualifications, and should produce evidence of successful teaching and experience in laboratory work. They must be medically fit.
The subjects taught in the schools are Mathematics, Applied Mechanics, Magnetism and Electricity, Heat, Steam, Metallurgy, Mechanical Drawing and English.
Salary scale £180—£10—£340—£15—£460.
There is a War Bonus varying from £153 17s. 6d. for the minimum point on the scale up to £351 7s. 6d. for the maximum.
The selected candidate will be required to commence his duties about 1st August next.
Applications should be addressed to
THE SECRETARY OF THE ADMIRALTY (C.B.),
Whitehall,
London, S.W. 1. G 757

DARLINGTON EDUCATION COMMITTEE.

TECHNICAL COLLEGE.
Principal—R. M. CAVEN, D.Sc.

Applications are Invited for

the following POSTS:—
(a) HEAD OF THE DEPARTMENT OF ELECTRICAL ENGINEERING, PHYSICS and PURE MATHEMATICS. Commencing Salary £350 per annum, rising by annual increments of £12 10s. to £400. Applicants are required to be Graduates of British Universities.
(b) ASSISTANT LECTURER IN ENGINEERING. Commencing salary £300, rising by annual increments of £12 10s. to £350. Preference will be given to Graduates of British Universities with Practical Engineering experience.
Further particulars and Forms of Application may be obtained from the undersigned, to whom completed Forms should be returned not later than the 12th June, 1920.—A. C. BOYDE, Director of Education and Secretary.—May, 1920. G 703

GLAMORGAN EDUCATION COMMITTEE.

APPOINTMENTS OF LECTURERS IN MECHANICAL AND ELECTRICAL ENGINEERING.

The Committee propose to

Appoint Two Travelling

LECTURERS in mechanical and electrical engineering respectively. Applicants must possess special qualifications for teaching engineering and allied subjects. Successful candidates must devote their whole time to the duties and reside where directed by the Committee, and will be required to commence duties in September next.
Salary £250 per annum, rising by annual increments of £15 to a maximum of £450 with expenses according to scale. Regard may be had to previous full-time teaching experience in a recognised efficient school in assessing the commencing salary, subject in the case of service under other Authorities to a limit of 10 years. Canvassing will disqualify.
Applications, on forms which will be supplied on receipt of a stamped addressed foolscap envelope, must reach the CHIEF EDUCATION OFFICIAL, County Hall, Cardiff, by the 18th June, 1920. G 742

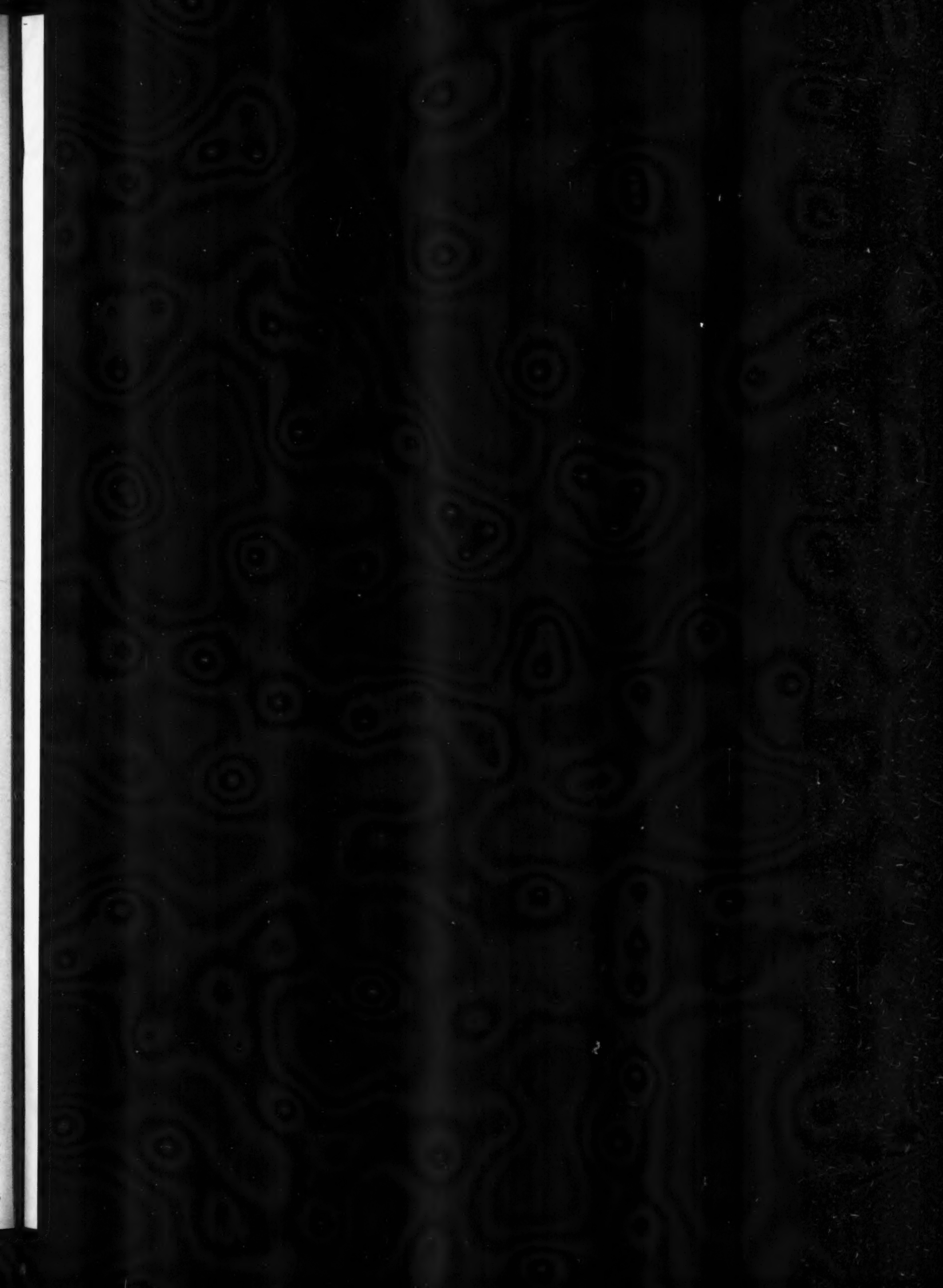
LONDON COUNTY COUNCIL.

TECHNICAL ASSISTANTS, FIRE BRIGADE.

Applications are Invited for

the APPOINTMENT in the Department of the Chief Officer of the Fire Brigade of:
(I) A Second Class TECHNICAL ASSISTANT (Section (a)), for the Engineering Subsection of the Inspection Section. Candidates must be under 25 years of age on 8th June, 1920. They should either have taken a course in mechanical and electrical engineering at a recognised training college, and should possess the necessary certificates or diplomas, or should have received in some other way a good theoretical and practical training. Some experience in a commercial firm or on engineering work under commercial conditions would be an additional qualification.
(II) A Non-classified TECHNICAL ASSISTANT, in the Workshop Section. Candidates must be under 26 years of age on 8th June, 1920. They should have received a recognised engineering education (theoretical), practical training as apprentice or pupil in engineering workshops, and practical experience in service with internal combustion engines.
The salaries are based on pre-war conditions and will be subject to temporary additions on the Civil Service scale, making the total commencing yearly remuneration approximately £303 17s. 6d. for the Assistant in the Inspection Section, and £353 17s. 6d. for the Assistant in the Workshops Section.
Candidates must be British subjects, and preference will be given to those who have served, or attempted to serve, with H.M. Forces, and particularly to those who have been disabled on war service.
Particulars and forms of application may be obtained from the CLERK OF THE COUNCIL, County Hall, Spring Gardens, S.W. 1. Stamped, addressed, foolscap envelope necessary. All communications must be marked "Technical Assistant, Fire Brigade," and application forms must be received not later than Eleven a.m., on Tuesday, 8th June, 1920.

JAMES BIRD,
Clerk of the London County Council.
G 705



THE DETERMINATION OF THE LOADS ON CRANE WHEELS.

By E. L. MONTAGNON, B.Sc.(Lond.), A.M.I.C.E.

IN the English text-books dealing with the design of cranes, very little attention has so far been paid to the subject of finding the loads transmitted to the crane wheels.

A method which is in fairly common use, but which does not lead to very satisfactory results, is shown by the following numerical example.

Consider a crane mounted upon four wheels spaced as shown in Fig. 1. Let the weights of the superstructure and substructure be 25 tons and 15 tons respectively, and let the former act at a distance of 2 ft. from the crane centre.

Then, with the jib lying across the wheel A, the load on that wheel is taken as

$$\frac{15}{4} + \left(25 \times \frac{5.6}{8} \times \frac{4.2}{6}\right) = 16.0 \text{ tons.}$$

If, however, the total weight of the crane be taken as acting at the centre of gravity of the superstructure and substructure, and the same method of taking moments is adopted, the load on A becomes

$$40 \times \frac{5}{8} \times \frac{3.75}{6} = 15.625 \text{ tons.}$$

The discrepancy noted between the two cases is even more marked with certain dispositions of the load and spacing of the wheels.

The problem is really statically indeterminate, but if the crane structure is assumed to be rigid, and the track level, it is possible, by employing a slightly different method of taking moments, to obtain identical wheel loads, whether the upper and lower portions of the crane are treated separately or combined at their common centre of gravity.

Considering the case dealt with above, the 25 tons weight of the top part acting at 2 ft. from the centre may be replaced by a load of 25 tons at the centre (making 40 tons total), together with a moment $25 \times 2 = 50$ ton-ft. in the plane of the jib. By resolving this moment along the two axes, the following wheel loads are obtained:—

$$A = \frac{40}{4} + \frac{25}{2}\left(\frac{1.6}{8} + \frac{1.2}{6}\right) = 15 \text{ tons.}$$

$$B = \frac{40}{4} + \frac{25}{2}\left(\frac{1.2}{6} - \frac{1.6}{8}\right) = 10 \text{ tons}$$

$$C = \frac{40}{4} - \frac{25}{2}\left(\frac{1.6}{8} + \frac{1.2}{6}\right) = 5 \text{ tons}$$

$$D = \frac{40}{4} + \frac{25}{2}\left(\frac{1.6}{8} - \frac{1.2}{6}\right) = 10 \text{ tons}$$

Similarly, if the whole weight of 40 tons be taken as acting at the common centre of gravity, then by using the same principle the wheel loads become

$$A = \frac{40}{4} + \frac{40}{2}\left(\frac{1}{8} + \frac{0.75}{6}\right) = 15 \text{ tons}$$

$$B = \frac{40}{4} + \frac{40}{2}\left(\frac{0.75}{6} - \frac{1}{8}\right) = 10 \text{ tons}$$

$$C = \frac{40}{4} - \frac{40}{2}\left(\frac{1}{8} + \frac{0.75}{6}\right) = 5 \text{ tons}$$

$$D = \frac{40}{4} + \frac{40}{2}\left(\frac{1}{8} - \frac{0.75}{6}\right) = 10 \text{ tons}$$

which are identical with those found by treating the top and bottom parts separately.

As the crane jib rotates, the centre of gravity of the whole crane and load describes a circle about the centre of rotation, and it is important to find the position of the jib which will produce the greatest load on any given wheel.

If the load on wheel D be calculated for different positions of the jib and plotted radially along the jib direction, a curve is obtained as shown in Fig. 2. This curve is a load influence line for the wheel D, and it shows that the maximum load on D occurs when the jib is perpendicular to the diagonal A C.

This can also be proved analytically as follows:

Let the jib be at an angle θ as shown in Fig. 2, then by putting $x = r\cos\theta$; $y = r\sin\theta$, the load on wheel D becomes:

$$\frac{W}{4} + \frac{Wr}{2}\left(\frac{\cos\theta}{a} + \frac{\sin\theta}{b}\right). \quad . \quad . \quad (1)$$

where W is the total weight of the crane and load.

This expression is greatest when

$$\frac{\cos\theta}{a} + \frac{\sin\theta}{b}$$

is a maximum, *i.e.*, when

$$\frac{d}{d\theta}\left(\frac{\cos\theta}{a} + \frac{\sin\theta}{b}\right) = 0.$$

i.e. when $\tan\theta = \frac{a}{b}$

Thus the position of the jib for maximum load at D can be found very readily by placing it perpendicular to the diagonal A C. The jib positions giving maximum load on the other wheels can be found in a similar manner.

If the value $\theta = \tan^{-1}\frac{a}{b}$ be inserted in equation (1), we have the maximum load on a wheel given by the expression:

$$\frac{W}{4} + \frac{Wr}{2}\frac{\sqrt{a^2+b^2}}{ab} \quad . \quad . \quad . \quad (2)$$

The greatest value of r for all four wheels to take load (apart from considerations of stability) is $r = \frac{ab}{\sqrt{a^2+b^2}}$ in which case the maximum wheel load becomes $\frac{W}{2}$.

If the ratios $\frac{a}{b}$ and $\frac{r}{b}$ be denoted by k and C, respectively, then the proportion of the total weight W carried by the most heavily loaded wheel is shown in Fig. 3.

To obtain the maximum wheel load, project the value of k vertically to meet the curve, then project horizontally to meet the inclined line corresponding to the value of C. This latter intersection will indicate the maximum load which is seen never to exceed $\frac{W}{2}$.

As an example, take the case of a crane mounted on four wheels having a wheel base of 10 ft., and the rail centres at 5 ft. apart. Let the weight of the whole crane and load be W and let the centre of gravity be at 1·25 ft. from the crane centre. Then for this example the value of k is $\frac{10}{5} = 2$, and the value of $C = \frac{1.25}{5} = 0.25$.

The ordinate corresponding to $k = 2$ meets the curve at the point P, and a horizontal line from P intersects the inclined line relating to $C = 0.25$ at the point Q. This indicates that the maximum load on a wheel under these conditions is 0·39 W.

If, as often happens when a revolving jib crane is mounted on a high gantry, the wheel base is less than the distance between the rail centres, the equation (2) and the curve, Fig. 3, can be made to apply by always taking a to be the greater and b the smaller of the two dimensions.

It may also be noted that Fig. 3 indicates the maximum load on a corner of a fixed crane mounted on four supports.

Reverting to Fig. 2, it is useful to find the boundaries within which the combined centre of gravity must always lie to ensure that each of the four wheels bears load.

Let the centre of gravity be distant x and y from the axes as indicated, then the load on wheel B is:

$$\frac{W}{4} - \frac{W}{2}\left(\frac{x}{a} + \frac{y}{b}\right).$$

This is zero when

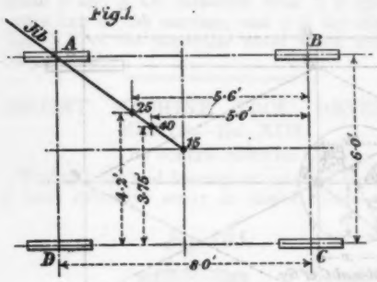
$$\frac{x}{a} + \frac{y}{b} = \frac{1}{2}, \text{ i.e., when } y = b\left(\frac{1}{2} - \frac{x}{a}\right).$$

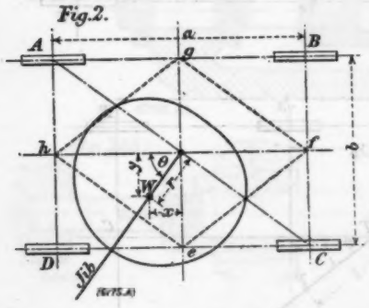
This equation, when plotted, gives the straight line $e\,h$ within which the centre of gravity must fall for the wheel B to take load.

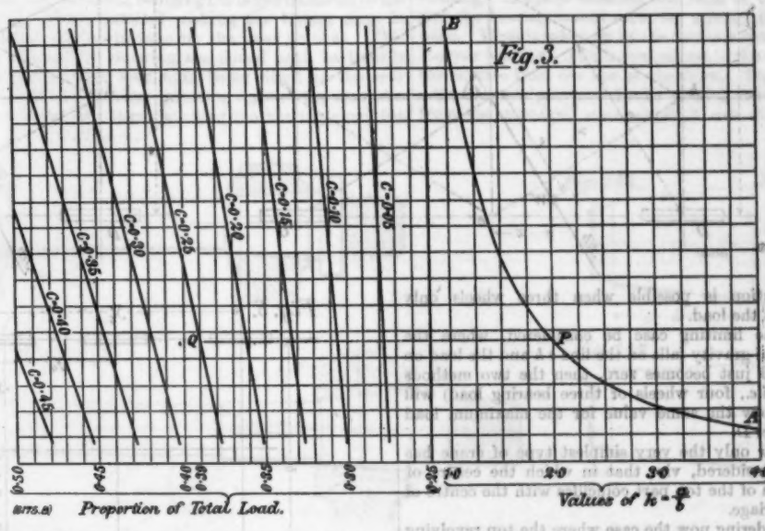
By similar reasoning the three other lines $h\,g$ $g\,f$ and $f\,e$ are found corresponding to zero load on the wheels C D and A respectively. Thus, assuming the track to be level, the centre of gravity must always lie within the figure $e\,f\,g\,h$ for all four wheels to carry load.

The method used above will be seen to be analagous to that employed in finding the "core" of a rectangular section, and takes no account of the stability of the crane.

Referring again to Fig. 2, if, with the jib in about the position shown, the centre of gravity falls outside the rectangle $e\,f\,g\,h$, then the above method of finding the wheel loads does not apply as the result will be found to give a negative load (*i.e.*, tension) at wheel B. This cannot happen unless







the crane carriage be secured by clips to the track, in which case the negative load found at B will be the pull to be taken by the clip.

To find the wheel loads when one wheel, say B, is out of action, the following method may be used.

It can be shown that the greatest load at D occurs when the jib is perpendicular to the line A C, *i.e.*, the same position as when all four wheels are taking load. Then maximum load at D, by moments about line A C

$$= \frac{Wr}{p} = \frac{Wr}{a\cos\theta} = \frac{Wr\sqrt{a^2+b^2}}{ab} \quad . \quad (3)$$

The loads on the other two wheels are:

Load at A, by moments about line C D

$$= \frac{W}{b}\left(\frac{b}{2} - y\right) = \frac{W}{b}\left(\frac{b}{2} - r\sin\theta\right)$$

Load at C, by moments about line A D

$$= \frac{W}{a}\left(\frac{a}{2} - x\right) = \frac{W}{a}\left(\frac{a}{2} - r\cos\theta\right)$$

The sum of these wheel loads as found above clearly equals W, and it can be proved that no other distribution is possible when three wheels only support the load.

If the limiting case be considered, where the centre of gravity falls on the line $e h$ and the load on wheel B just becomes zero, then the two methods given (*i.e.*, four wheels or three bearing load) will each show the same value for the maximum load on wheel D.

So far only the very simplest type of crane has been considered, viz., that in which the centre of rotation of the top part coincides with the centre of the carriage.

Considering now the case where the top revolving part of the crane is not placed centrally on the carriage, but is in a position such as T in Fig. 5, the combined centre of gravity of the top part and the substructure describes a circle as the jib rotates but is not at any given instant in the same vertical plane as the jib, as it was in the former cases considered.

Let S be the weight of the substructure and P that of the revolving part, with T as the centre of rotation distant m from the carriage centre. Let P act at l from T.

Then if x and y are the co-ordinates of the combined centre of gravity measured from S as origin, we have, by taking moments about the lines $e g$ and $h f$ respectively:

$$x = \frac{P(m + l\cos\theta}{P+S}; \quad y = \frac{Pl\sin\theta}{P+S},$$

from which

$$\left(x - \frac{Pm}{P+S}\right)^2 + y^2 = \left(\frac{Pl}{P+S}\right)^2$$

giving the locus of the centre of gravity as a circle of radius $\frac{Pl}{P+S}$ and with its centre on the line $h f$ distant $\frac{Pm}{P+S}$ from S. From the geometry of the figure, it is apparent that the radius of the circle described by the centre of gravity is always parallel to the direction of the jib.

The load on wheel D

$$= \frac{P+S}{4} + \frac{P}{2a}\left(m + l\cos\theta\right) + \frac{P}{2b}\left(l\sin\theta\right).$$

This is a maximum when $\tan\theta = \frac{a}{b}$, *i.e.*, with the jib perpendicular to the diagonal A C as found for the previous case, with the top part at the centre of the carriage.

By putting in the values

$$\cos\theta = \frac{b}{\sqrt{a^2+b^2}} \text{ and } \sin\theta = \frac{a}{\sqrt{a^2+b^2}}$$

we have the maximum load on

$$D = \frac{P+S}{4} + \frac{P}{2}\left(\frac{m}{a} + \frac{bl}{a\sqrt{a^2+b^2}} + \frac{al}{b\sqrt{a^2+b^2}}\right)$$

which reduces to

$$\frac{W}{4} + \frac{P}{2ab}\left(bm + \frac{l}{1}\sqrt{a^2+b^2}\right) \quad . \quad (4)$$

where $W = P + S$, the same result as would have been obtained had the top part and lower part been taken together.

In this case also the condition holds that for all the wheels to be loaded, the centre of gravity must fall within the figure $e f g h$.

The only type of crane that has so far been considered is that having two axles and four wheels, and the wheel loads found above may be taken to apply whether the crane is or is not mounted on springs.

Dealing now with the general case of a crane with any number of axles unequally spaced, the position of the jib for maximum load on a wheel may be found as follows:—

Number of wheels $= n$.

Let Y Y be a line passing through the centre of gravity of the axles, and let S be the weight of the substructure acting at its centre of gravity distant p from Y Y. (Fig. 6.)

Let T be the centre of rotation distant m from Y Y and P the weight of the revolving part and load acting at a distance l from T. Then with the jib in the position shown, the load on wheel A becomes:

$$\frac{P+S}{n} + \frac{Sp\,y_3}{2\Sigma y^2} + \frac{P(m + l\cos\theta)\,y_3}{2\Sigma y^2} + \frac{2Pl\sin\theta}{nb}$$

where

$$\Sigma y^2 = y_1^2 + y_2^2 + y_3^2 + y_4^2 + y_5^2 + \ldots$$

In any particular case θ is the only variable, and the greatest load on A will occur when

$$\frac{y_3\cos\theta}{2\Sigma y^2} + \frac{2\sin\theta}{nb}$$

is a maximum, *i.e.*,

$$\tan\theta = \frac{4\Sigma y}{nby_3}$$

Putting

$$P + S = W; \quad \cos\theta = \frac{nby_3}{\sqrt{(nby_3)^2 + (4\Sigma y^2)^2}}$$

and

$$\sin\theta = \frac{4\Sigma y^2}{\sqrt{(nby_3)^2 + (4\Sigma y^2)^2}}$$

we have for the maximum load on

$$A = \frac{W}{n} + \frac{Spy_3 + Pmy_3}{2\Sigma y^2} + \frac{Pl}{\sqrt{(nby_3)^2 + (4\Sigma y^2)^2}}\left(\frac{nby_3^2}{2\Sigma y^2} + \frac{8\Sigma y^2}{nb}\right)$$

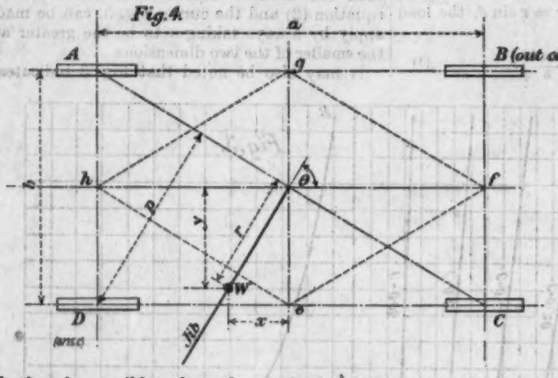
which reduces to:

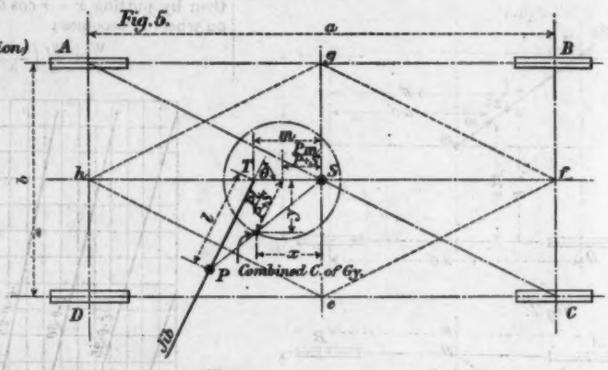
$$\frac{W}{n} + \frac{1}{2\Sigma y^2}\left\{y_3(Sp + Pm) + \frac{Pl}{nb}\sqrt{(nby_3)^2 + (4\Sigma y^2)^2}\right\} \quad (5)$$

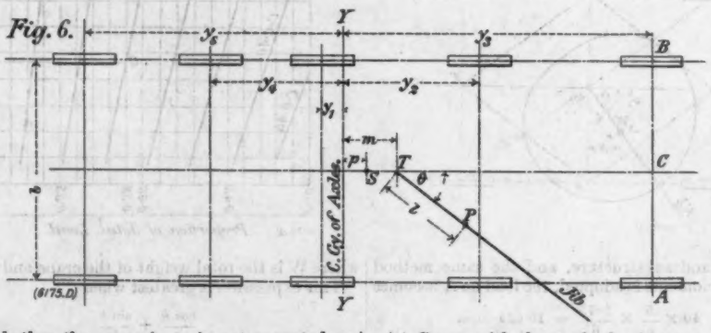
If the jib be parallel to the track as at T C in Fig. 6, by putting $\theta = 0$ the load on each of the wheels A and B becomes:

$$\frac{P+S}{n} + \frac{y_3}{2\Sigma y^2}\left[Sp + P(l+m)\right] \quad . \quad (6)$$

Special Cases of (5).







(*a*) Crane with four wheels, but top part not central on the carriage.

Let

$$n = 4; \; p = 0; \; \Sigma y^2 = 2\left(\frac{a}{2}\right)^2 = \frac{a^2}{2}; \; y_3 = \frac{a}{2}$$

substituting these values in (5) we have:

Maximum load on A

$$= \frac{W}{4} + \frac{1}{a^2}\left\{\frac{Pma}{2} + \frac{Pl}{4b}\sqrt{(2ab)^2 + 4a^4}\right\}$$

$$= \frac{W}{4} + \frac{Pm}{2a} + \frac{Pl\sqrt{a^2+b^2}}{2ab}$$

as equation (4) above.

(*b*) Crane with four wheels and with top part central on carriage.

Put Wr for Pl and $m = 0$.

then maximum load on A

$$= \frac{W}{4} + \frac{Wr\sqrt{a^2+b^2}}{2ab}$$

as equation (2) above.

The equations (5) and (6) will apply to cranes mounted on springs, and involve the assumptions (*a*) that the crane carriage is rigid and (*b*) that the track is level.

For a crane without springs it is clear that if the track is such that it can be taken as possessing the same degree of elasticity at all parts, this will be practically equivalent to mounting the crane on

springs, and the equations (5) and (6) may then be used for finding the wheel loads.

If the upper and lower parts of the crane be taken together by the method of Fig. 5, the co-ordinates of the common centre of gravity measured from Y Y, and the centre line of the carriage will be:

$$\frac{Sp + P(m + l\cos\theta)}{W} \text{ ; and } \frac{Pl\sin\theta}{W}$$

Calling these x and y respectively, the maximum load on wheel A becomes:

$$\frac{W}{n} + \frac{Wxy_3}{2\Sigma y^2} + \frac{2Wy}{bn} \quad . \quad . \quad . \quad (7)$$

which is a reduced form of equation (5).

It should be noted that in obtaining the expressions (5), (6) and (7), it has been taken that all the wheels are bearing load. The figure within which the centre of gravity must lie for all wheels to be loaded may be found in a similar manner to that used for the case of four wheels.

The equations of the boundary lines corresponding to *e.f.g.h* of Fig. 2, are in the present case:

$$y = \frac{b}{2} - \frac{bnq}{4\Sigma y^2}\, x$$

where x and y are measured from Y Y and the centre line of the carriage, and q is the distance from Y Y of the particular wheel which will first take no load.

RECENT MACHINE TOOL DEVELOPMENTS.—No. XIII.

By JOSEPH HORNER.

THE spindles and bearings of machine tools offer a most extensive study in varied designs. The high speeds employed in many cases, the absolute need for securing, and preserving accuracy of fitting and movements, both in circular and longitudinal directions, the necessity of providing against the effects of varying temperatures, the protection from ingress of dirt and, in the grinding machine spindles of the abrasives, the adoption of suitable means for the attachment of chucks, of work, or of tools, varying in dimensions and shapes, require an immense variety of adaptations and fittings, which must fulfil well-defined conditions. Suitable outlines are necessary, appropriate materials, correct dimensions, balance, lubrication, readiness of attachment of accessories, often united with some automatic provisions—conditions that are not fulfilled in the same way in all the great groups of machine tools. They differ in the lathes, the automatics, the drills, the grinders, the gear cutters, the milling machines, and in the slow-running heavy spindles, and the small high-speeded spindles. And in addition, the views of designers, and firms afford examples of many variations in details.

Early Lathe Spindles.—The prototype of all machine spindles must be sought either in the lathe or in the drilling machine—the old drill press. Parallel journal necks of small diameter, and abbreviated in length, invited the inevitable rapid wear. The capped bearings providing for take-up of wear could not secure permanent alignment in rapidly-wearing spindles. End thrust was taken on a point centre, or on a flat, in opposition to a collar making contact with the rear of the front bearing, causing the effects of expansion with heat to be felt over practically the entire length of the spindle. Long ago, the parallel divided bearings gave place in the smaller lathes, but not in the largest, to the solid coned journal bearings in which wear is taken up by thrusting the mandrel deeper into the cones. The latter were of hardened shear steel, taking the place of the gun-metal in the divided bearings. Many variations might be seen in the old coned lathes. The evil of seizing was not uncommon in heated spindles having journal cones of low angles, made of steel imperfectly hardened, and not lapped carefully. In these matters some firms achieved a much higher reputation than others did. In the earlier designs, the smaller diameter of the front cone came next the nose, which limited the diameter of the nose screwed to receive chucks, with corresponding lessening of the wearing capacity there. To avoid this reduction the direction of the front cone was reversed, bringing the larger diameter to the front, which entailed making the hinder cone in such a way as to take up the wear on that. This is effected by drawing the coned neck backwards in its bearing, lock nuts being fitted at the rear part of the mandrel, pressing against the rear of a coned bearing there, pushing the bearing along the parallel part of the mandrel on which it is splined. The cones are set in reverse directions. To prevent risk of seizing, the pressure is relieved by a stop pin in the bridge at the back of the headstock. In many of the old lathes the risk of seizing was eliminated by the device of the double cone. The major portion of the length was made with a low angle, but it was backed with a short steep angle of 45 deg., in opposition to which the thrust of the tail pin was taken. Examples of this may still be seen, and in the absence of the tail pin.

Fig. 265 is an old mandrel of small dimensions, in which the cones slope in the same direction. Both necks are held back, and adjusted in their journals with the three lock nuts behind the rear journal, in conjunction with the adjustment of the tail stop pin, that takes the end thrust, and which in opposition to the cone adjustments, effected by the three lock nuts, prevents the bearings from seizing.

Figs. 266 and 267 show two standard necks, an earlier and a later one. The first has a taper of one in four, reckoned on diameter, the second, of one in six. The length L is one and one-third of the larger diameter D, which is too short for durability, according to present-day views. Fig. 268 is a better design, provided the fitting is good, and means of readjustment perfect. It represents the standard form, when the cones are retained. The front cone has its larger diameter facing towards the front, in order to have the screwed nose of the largest size practicable. The chucks abut against the collar to ensure accuracy of setting, and true running. A space between the back of the collar and the bearing leaves room for movement due to wear. Wear is taken up by the two lock nuts behind the rear bearing. This is conical, set in the direction the reverse from the one at the front. Its endlong adjustment is provided for by making it separately from the mandrel, over which it can slide on a parallel length into which a sunk key is fitted to drive the journal neck. The adjustment of the lock nuts alone would not prevent seizing. End pressure is therefore taken against the stop pin in the bridge piece, shown in section, which is secured

Fig. 265.

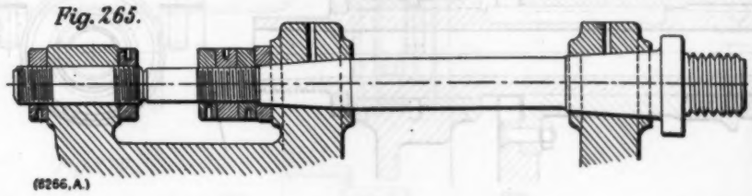


Fig. 266.

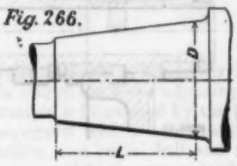


Fig. 268.

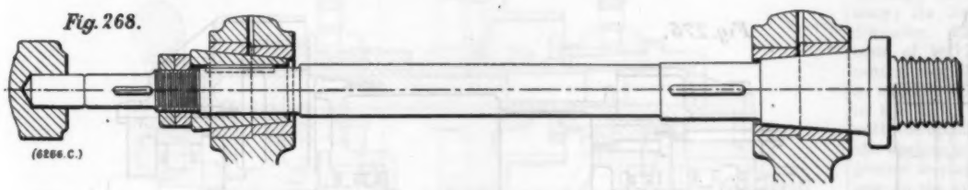


Fig. 267.

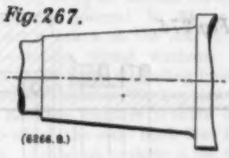


Fig. 269

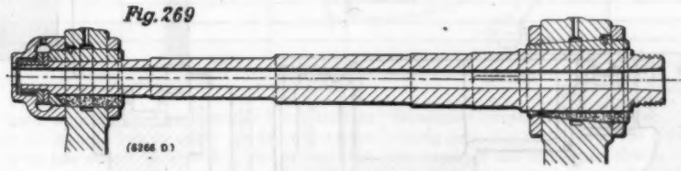


Fig. 270.

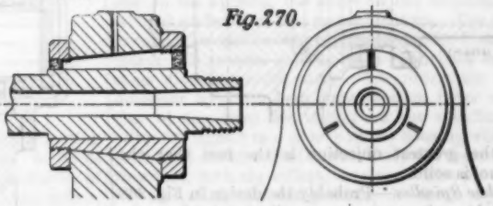
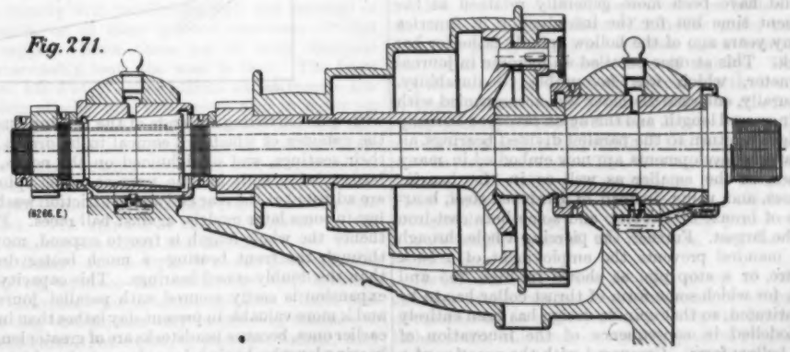


Fig. 271.



with pillar bolts at the rear of the headstock. The bush bearings at front and back are, for convenience, fitted into parallel shouldered seatings bored in the headstock.

There are several objectionable features about this type of mandrel which account for its present lessening employment in lathe practice. These are: its tendency to seize at high speeds, consequent on the absence of provisional adjustments for changes in temperature, which become more apparent with increases in length, the very unsatisfactory character of the lubrication, and slightly perhaps that the cones change in diameter with endlong adjustments.

Fig. 272.

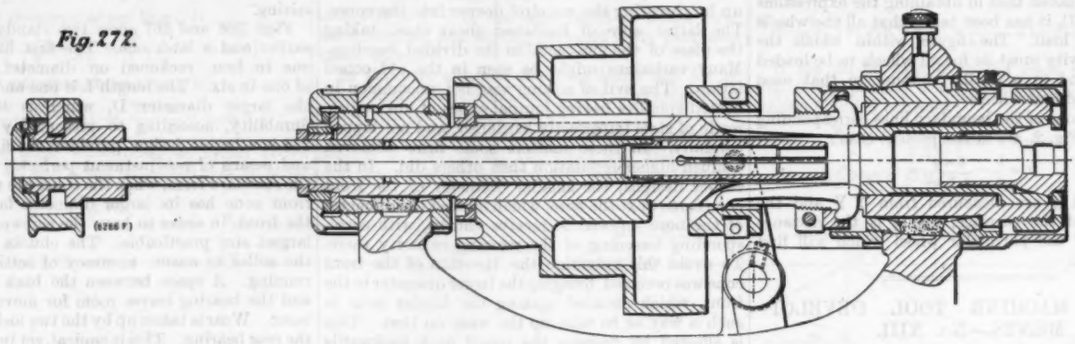


Fig. 273.

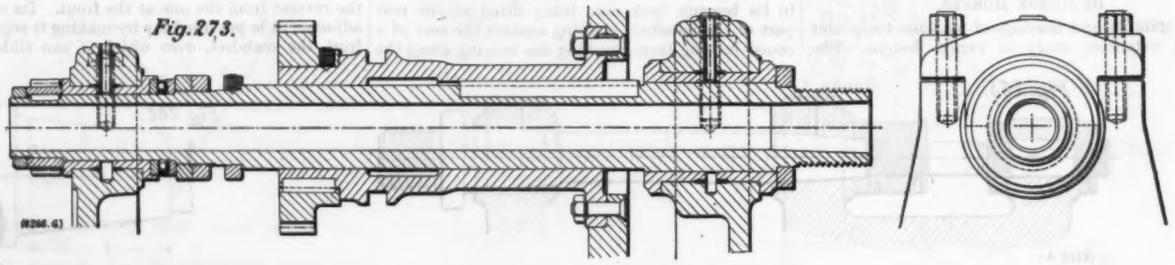


Fig. 274.

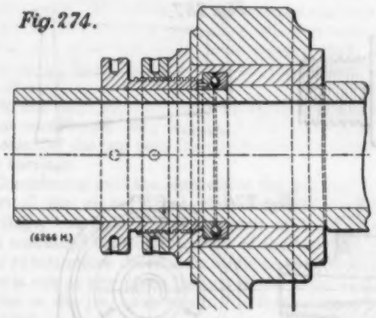
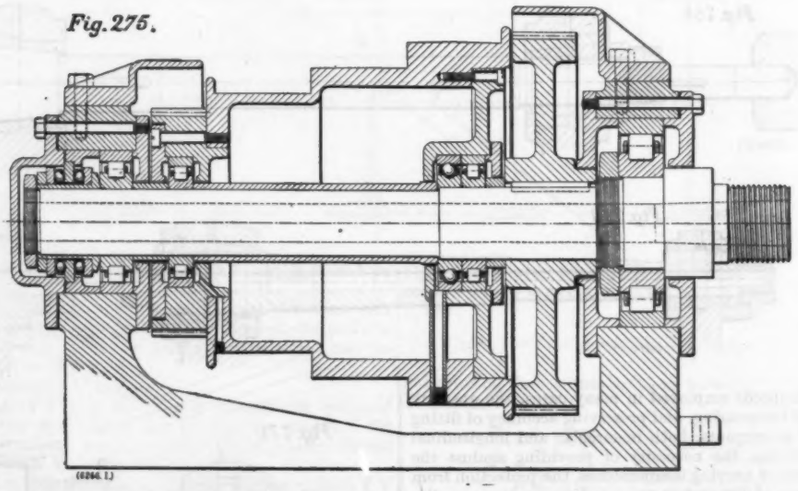


Fig. 275.



But the greatest objection is the fact that the mandrel is solid.

Hollow Spindles.—Probably the design in Fig. 268 would have been more generally retained at the present time but for the introduction in America many years ago of the hollow spindle lathe for bar work. This at once entailed an increase in journal diameter, which was favourable to durability. Naturally, enlarged diameter was accompanied with an increased length, and this again favoured in many designs a return to the parallel divided bearings, all of which developments are now embodied in many lathes, in the smaller as well as in the heavier classes, and using, instead of hardened steel, bearings of bronze or babbitt, and sometimes cast-iron in the largest. Further, the piercing a hole through the mandrel prevents the employment of a back centre, or a stop pin, as shown in Figs. 265 and 268, for which some form of thrust collar has to be substituted, so that spindle design has been entirely remodelled in consequence of the innovation of the hollow form. Compared with the practice of a few years since, the spindles of the best lathes assume rather mammoth proportions.

Associated with this, though not necessarily dependent on it, has been the employment of improved methods of lubrication of the journal necks. The old coned necks were merely supplied frequently with oil from a can through a hole drilled from the top. This crude provision alone is rarely retained now, but means are provided for prolonging and distributing the supply so that very much less attention is called for on the part of the lathe man.

With some exceptions the hollow lathe spindles have parallel journal necks, a fact which, in association with the absence of a tail pin reduces the effects of rise in temperature since the spindles are nearly invariably tied at one end only, the remainder of the length being free to expand. Adjustments are made with nuts encircling the ends of the bearing bushes, the outsides of which are conical to be drawn into their seatings, and so tightened on the necks, the bushes being split for the purpose. The spindles are adjusted at the rear end against friction washers, but in some later models, against ball races. From thence the whole length is free to expand, moving through the front bearing—a much better design than the doubly-coned bearings. This capacity for expansion is easily secured with parallel journals, and is more valuable in present-day lathes than in the earlier ones, because headstocks are of greater length, bearing lengths having been increased to from one and a half times to double the older proportions. With increased length, and enlarged diameters, the pressure per unit area has been greatly lessened, concurrently with vastly improved methods of lubrication. The result is that very heavy cutting is done, while wear, with the need for take-up is delayed.

Fig. 269 shows one of the earlier forms of the hollow spindle design. The spindle, of steel, with necks hardened, runs in parallel bearings of hardened steel, ground, and lapped. Wear is taken up by closing the bearings on the journals, which is done with the lock nuts seen encircling them at front and rear, the bush bearings being split to provide the slight amount of elasticity necessary, and tapered on the outside to effect the closing-in when they are drawn through their seatings. The spindle, dating before the ball-race era, is coerced at the rear end, where the thrust is taken on a steel collar, adjusted with the boxed ring nut which also forms a cap to afford protection from ingress of dust. Elsewhere the bearings are not protected as they are in the newer designs. Lubrication is better than that in Fig. 268, but is not the best. A narrow, encircling oil well is provided, with saturated strips of felt let into recesses cut in the lower portions of the bush bearings.

Fig. 270 shows a variation on the previous form. The bush bearings are split in three places, nearly through at two locations, 120 deg. apart, and entirely through in the upper section. This split is closed at the ends with leather to form an oil reservoir. The bush is of babbitt, and is drawn along for adjustment with the ring nuts seen.

Figs. 269 and 270 are transitional forms, but are interesting so far as they indicate the trend of development. The lubrication is not perfect, the bearings are not protected, and the abutment collar for chucks is wanting. All these details have been the subjects of many variations in the hands of numerous manufacturers.

The proportions of spindle bearings, and the outlines of the spindles are mainly empirical. A mandrel has to carry all its load on the nose, so that the theoretical outline has been supposed to be parabolic. But the belt pull, and the gear pressures are thrown on the body of the mandrel, whence it follows that some stresses have to be sustained by the rear bearing. Design and practice have evolved ever-increasing dimensions for both bearings, but always the front is very much larger and longer than the rear one. If a comparison were made between journal dimensions of twenty or even ten years ago with those now made, the difference would be rather striking.

Fig. 271 is the spindle fitting of a lathe that has had more influence on development than perhaps any other single innovation in lathe design—the Hendey-Norton. The cluster gears, not shown, have been appropriated and modified not only in myriads of lathes, but in other kinds of machine tools, with the object of avoiding the delays that are inseparable from the practice of changing trains of gears anew for every different pitch of screw thread.

The spindle is hollow, and receives a draw-in collet chuck (not shown). The pinion seen at the rear is the one from which the gears for screw-cutting and feeding are primarily actuated. Coned bearings are fitted, facing in the same direction. The hinder coned bush fits with a driving key to the spindle. It is adjusted by turning the ring nut at its rear end. The outer nut which confines the pinion is used for effecting end adjustments of the end play of the spindle, pulling in opposition to the collar and washer at the spindle nose. The ring nut at the front of the hinder bearing confines the cone pulley endwise, while permitting it to run freely on the spindle. The lubricating and protecting arrangements show a great advance. The bearings hold a large volume of lubricant, are self-oiling, and are well protected at each end. Each bearing has a large hole for the introduction of lubricant, and an oil well for its reception. A loose ring encircling the centre of the journal throws the oil up with each revolution—the "ring-oiling" device adopted in so many modern lathes. Oilers (not seen) outside the bearings at the front show the height at the time of filling. Each bearing has protecting hoods prolonged at front and back to prevent escape of oil and ingress of dust. Oil thrown out at the ends drains back into the well.

Screw Machine Spindle.—A section through the spindle of a Brown and Sharpe screw machine is given in Fig. 272, including the opening and closing mechanism of the collet chucks. This has parallel bearings at both front and rear. The end thrust is taken at the rear of the hinder bearing, where washers of hardened steel and phosphor bronze are adjusted by the encircling cap nut seen. The bearings of phosphor bronze are adjusted with the nuts on each end. The front bearing is protected with long parallel hoods extending over its front and back ends, the first being secured with grub screws on the outside of the adjusting nut, the second being an extension of the nut there. The capped nut on the hinder bearing both protects it and adjusts the friction washers. Both bearings have a well reservoir and distributing channels.

Heavy High-Speed Lathe.—Fig. 273 is the main spindle of a high-speed, all-geared, head by the Britannia Company, of Colchester. The first motion sliding gears are included in the drawing. So far as the bearings are concerned this is representative of one of the types long in use for the heavier lathes, those namely with parallel journals and bearings of gun-metal or of close grained cast-iron, divided and capped. Since these are of large diameter and reasonably long, the wear is slow. The front journal has a steel collar shrunk on, to receive the abutting chucks, and this serves also to cover up and protect that end. An innovation here is a ball thrust. One half its cage is recessed into the flange of the journal bearing, the other half is maintained in place with the lock nuts screwed over the spindle. The lubrication of the journals possesses no special features. The spindle, 4 in. in diameter in the front bearing, has a 2-in. hole through it.

Ball Races.—In the light of recent developments a very big advance was made when ball bearings were introduced for machine spindles. Used first for taking end thrusts only in place of washers of hardened steel, gun-metal, or phosphor bronze, they are now employed both for end thrusts and radial pressures. In some cases, the two are combined in one race, but only for spindles upon which light duty is imposed. Generally, separate bearings are fitted to receive the two classes of pressures. In some again provision is made for alternating thrusts. Much of this improvement must be accredited to the better methods of manufacture of balls and races that have been adopted in recent years in response to the more stringent requirements of machine-tool builders and others. In the old designs the loosely-arranged circles of balls were mutually destructive, since they were in contact with one another as well as with their races. Nor were their sizes produced within such fine limits as at present, with the result that the entire pressure might be concentrated on a few balls only, instead of being equally distributed over the whole. Nor were the best results that were possible secured by the selection of the most suitable alloy steel, with its most correct heat treatment, so precisely as they are now. Nor was the division between thrusts and radial pressures so carefully observed. If these older faulty conditions had not been ameliorated, the ball races now becoming so common would have failed to come into use.

An early method of fitting of a ball race to a lathe spindle, to take the thrust only at the rear bearing, is shown by Fig. 274, in this the method of fitting differs from that in Fig. 273. The race on the right runs with the spindle, the one on the left is fixed, being pinned to the end of the outer adjusting nut.

An advanced example is illustrated by the headstock, Fig. 275, equipped with a combination of Hoffmann ball thrusts, and radial ball and roller bearings, the lathe being of 8½ in. centres for heavy duty; its front spindle journal is 3½ in. in diameter. The thrust is taken at the rear on two rows of ball races—double thrust washers. The central race fits in a recess in its encircling housing, in which it is secured by its faces, having clearance in the bore. The flanking washers revolve along with the spindle, to which the steel bush that holds the washers is fitted. Adjacent to these is the roller journal having inner and outer races fitting tightly, one on the spindle, the other in the housing, and secured endwise in the manner shown. The front journal is carried in very substantial roller bearings, which will sustain greater loads than balls of the same diameter could carry. The rollers are 1 in. diameter by 1 in. long, separated in brass cages. One of the races fits tightly on the spindle, the other fits tightly in a groove in the housing which is prolonged to form dust caps. Only the inner race, therefore, with the rollers, revolves. The provision for alterations in temperature is made by the freedom for longitudinal movements permitted by the sliding of the rollers within the outer race. The belt pulley is carried on two roller bearings, with inner and outer races secured tightly. Here, too, the rollers can slide longitudinally with changes in temperature. A ball race adjacent to the front roller bearing of the belt cones locates the pulley endwise, but carries no portion of the load, the outer race having clearance. The bearings are provided with a solid lubricant packed in the housings. These include the protecting caps seen, which are brought down closely to the revolving parts, with a very slight amount of clearance, and having annular grooves.

Thrust Collars.—There is one group of lathe spindles which has not been subjected to so great developments as those just noted. In the heaviest lathes of all, which run slowly, the journal bearings, as of old, are divided and parallel, of gun-metal or cast-iron, and the mandrels are often of cast-iron and solid. And the thrust is taken on collars in the rear bearing. The conditions of service are wholly different from those of the groups of smaller lathes.

Fig. 276.

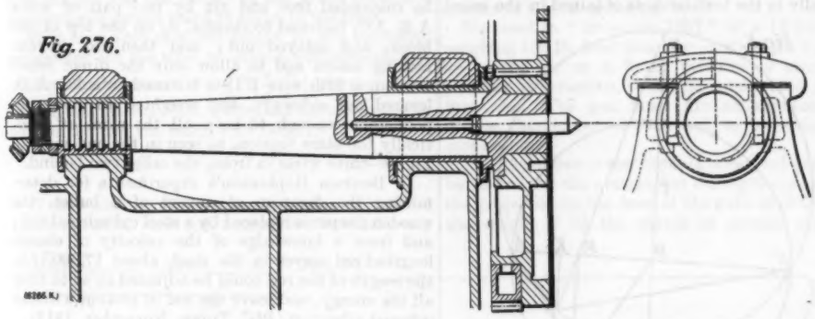


Fig. 277

Fig. 278.

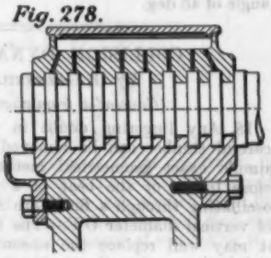


Fig. 279.

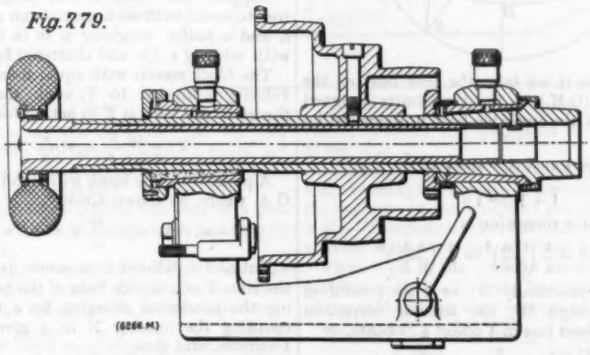


Fig. 276 shows the mandrel of a heavy turbine lathe. The front journal is 15 in. diameter by 24 in. long, the hinder journal measures 11 in. diameter over the thrust collars, by 17 in. long. The bearings are divided brasses, the lower halves being semi-circular, the upper, "square." The mandrel is adjusted endwise by the rear lock nuts. The face plate with its ring of teeth is a permanent fitting on the nose, being bolted on. The point centre is pushed out by driving a drift into the hole made at right angles in the mandrel.

A method of lubricating bearings of the thrust collar type is shown by Figs. 277 and 278. A reservoir in the cap feeds distributing channels going to each collar. Waste lubricant is collected in the trough at the end.

Small Bench Lathes.—Passing to the other extreme in dimensions, Fig. 279 shows the headstock of a Pratt and Whitney bench lathe, with a spindle measuring 1 in. outside diameter, and having a hole pierced through it. The bearings are reversed cones, each adjusted with a single protecting nut. The front bearing has the double cone previously mentioned—the greater portion of the length being made with a small angle, but backed with a steep angle of 45 deg.

COLLISION DYNAMICS.

By G. GREENHILL.

(*Concluded from page* 670.)

18. Any lingering doubt in the mind of the careful thinker can be removed by the following simple exact geometrical method, which assigns close limits of the beat of a pendulum bob P, oscillating through a finite arc A O A′, on a circle of vertical diameter O E. The method is so easy, it may well replace the unconvincing appeal to simple (harmonic) vibration in the usual elementary treatment.

The to and fro oscillation of P is compared with the continuous motion of a satellite point S, in a complete circuit round a circle.

Join E P cutting A A′ in R, and draw the ordinate R S of the horizontal circle on the diameter A A′, shown rebatted on the vertical plane in the figure (Fig. 8).

The velocity of P is that acquired in falling freely the depth P K vertical below A A′. This is the one dynamical principle required, and the rest is geometry; and then

$$(\text{vel of P})^2 = 2g\,.\,\text{PK} = \frac{2g}{\text{OE}}\,\text{AP}\,.\,\text{PA}' = n^2\,\text{AP}\,.\,\text{PA}'$$

by Euclid VI C, and putting $\frac{2g}{\text{OE}} = \frac{g}{l} = n^2$, as before. Thus P reaches O with velocity $n\,.\,\text{AO}$, as required in the theory of the ballistic pendulum.

From the similar triangles A R P, E R A′ and A′ R P, E R A,

$$\frac{\text{AP}}{\text{AR}} = \frac{\text{EA}'}{\text{ER}} = \frac{\text{EA}}{\text{ER}} = \frac{\text{PA}'}{\text{RA}'},\quad \frac{\text{AP}\,.\,\text{PA}'}{\text{AR}\,.\,\text{RA}'} = \frac{\text{EA}^2}{\text{ER}^2}.$$

Since E P, E R = E A², and E P cuts the circle A P A′ and the straight line A R A′ at the same angle,

$$\frac{\text{vel. of R}}{\text{vel. of P}} = \frac{\text{ER}}{\text{PP}} = \frac{\text{ER}^2}{\text{EA}^2},$$

$$(\text{vel. of R})^2 = (\text{vel. of P})^2\,\frac{\text{ER}^4}{\text{EA}^4}$$

$$= n^2\,.\,\text{AP}\,.\,\text{PA}'\,.\,\frac{\text{ER}^4}{\text{EA}^4} = n^2\,.\,\text{AR}\,.\,\text{RA}'\,.\,\frac{\text{ER}^2}{\text{EA}^2},$$

and since A R . R A′ = R S²

$$\text{vel. of R} = n\,.\,\text{RS}\,.\,\frac{\text{ER}}{\text{EA}},\quad \text{vel. of S} = n\,.\,\text{DS}\,.\,\frac{\text{ER}}{\text{EA}}$$

in the triangle of velocity D R S.

The angular velocity (A.V.) of S is then $n\,\frac{\text{ER}}{\text{EA}}$ round the centre D, fluctuating between the limits

$$n \text{ and } n\,\frac{\text{ED}}{\text{EA}} = n\cos\tfrac{1}{2}a,$$

if the thread oscillates to an angle a to each side of the vertical, and not the constant $n\sqrt{(\sec a)}$, as it would be if S moved round uniformly as a conical pendulum.

Thus

$$n > \text{A.V. of S} > n\cos\tfrac{1}{2}a,$$

$$\frac{2\pi}{n} < \text{period of S, the double beat} < \frac{2\pi}{n}\sec\tfrac{1}{2}a;$$

which proves that the beat of a pendulum in visible oscillation is always greater than π/n, and only undistinguishable from it when the oscillation is invisible.

And here it is only one step further to add the Elliptic Function statement of the continued motion of P; because the expression above for the angular velocity of S gives at once the angle A D S as Legendre's $\phi = \text{am } nt$ of Abel-Jacobi, with modular angle $\frac{1}{2}a$, and

$$\text{D R} = \text{D A}\cos\phi = \text{D A}\,\text{cn}\,nt,$$

$$\tan\tfrac{1}{2}\theta = \tan\tfrac{1}{2}a\,\text{cn}\,nt;$$

$$\text{E R} = \text{E A}\,\text{dn}\,nt,\ \text{O P} = \text{O A}\,\frac{\text{cn}\,nt}{\text{dn}\,nt} = \text{O A}\,\text{sn}\,(\text{K} - nt),$$

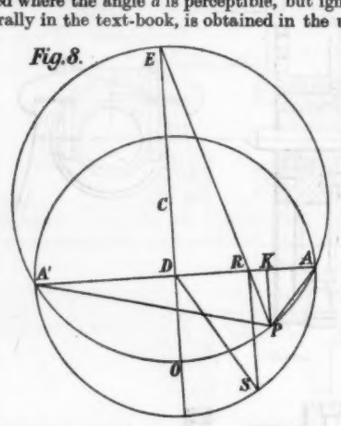
and the velocity of P is

$$n\,.\,\text{DA}\,\frac{\text{sn}\,nt}{\text{dn}\,nt} = n\,.\,\text{OA}\,\text{cn}\,(\text{K} - nt).$$

These elliptic functions degenerate into the ordinary circular functions of simple vibration, called harmonic vibration in the text book, when $a = 0$, and the oscillation is invisible, that is, cannot be observed.

In the visible oscillation of a clock pendulum, the "circular" correction of clock theory, required where the angle a is perceptible, but ignored generally in the text-book, is obtained in the usual

Fig. 8.



practical formula if we take the true beat as the geometric mean (G.M.) of the two limits assigned above, and then the invisible beat is increased by the factor

$$\sqrt{(\sec\tfrac{1}{2}a)} = (1 - \sin^2\tfrac{1}{2}a)^{-\frac{1}{4}}$$

practically

$$1 + \tfrac{1}{4}\sin^2\tfrac{1}{2}a$$

so that the circular correction is

$$\tfrac{1}{4}\sin^2\tfrac{1}{2}a = \frac{1}{4}\left(\frac{\text{O A}}{\text{O E}}\right)^2 = \frac{1}{16}\left(\frac{\text{A A}'}{\text{E A}}\right)^2$$

in which E A is practically $2l$; or if the pendulum is swinging through D°, the circular correction amounts to one beat lost in 4 $\text{cosec}^2\frac{1}{2}$ D beats, or

$$\frac{4}{\left(\frac{57.3}{\frac{1}{2}\text{D}}\right)^2}\frac{t}{l} = \frac{t}{210{,}000 \div \text{D}^2}.$$

This is 3,600 for D = 7° ·64, or 1 second beat in the hour, observable by the method of coincidences, described in "Matter and Motion."

In the Hope-Jones synchronome clock, the self-regulation is carried out by the circular correction.

The circular correction for a conical pendulum would be obtained from

$$\sqrt{(\cos a)} = (1 - \sin^2 a)^{\frac{1}{2}}$$

or

$$1 - \tfrac{1}{2}\sin^2 a$$

meaning one beat gained in 4 $\text{cosec}^2 a$ beats, or $52{,}500 \div \text{D}^2$; and this is 3,600 for D = 3° ·82.

In a clock an increase of the weight will cause the pendulum to swing through a larger angle, and the clock will lose.

In another method of exact treatment of pendulum motion the circle is described, centre O, through A and A′, and E P is produced to meet it in T, and the motion of the satellite point T is examined, and the fluctuation of its velocity in going round the circle, and its limits; and thence the limits of its period, and of the period to and fro of the pendulum between A and A′.

In the exact solution of the motion of T by the elliptic function and its comparison with the motion of S, a quadric transformation, so-called, arises; but this would take us too far at present, and we leave it as an exercise for the careful student.

19. Ballistic pendulum: this was invented by Benjamin Robins, 1740, for measuring the velocity of a bullet, receiving the impact on a heavy body suspended as a pendulum, and diluting the velocity in the same momentum distributed in a greater weight.

In its original form the ballistic pendulum swung back bodily in rotation about a horizontal axle, and a knowledge of its weight, preponderance, moment of inertia, centre of oscillation and percussion was required in a reduction of the experiment.

But this complication is avoided if the pendulum block is mounted to recoil horizontally, always parallel to itself; suspended freely by wires, which should be arranged on the Five Point principle.

None of the textbooks describe this application of Lord Kelvin's principles of Geometrical Fit, and the block is shown usually with a redundant number of suspensions, eight in the Hicks ballistic pendulum. The true principle was first used by Mr. A. Mallock, and described in the Proceedings of the Royal Society, November, 1904.

The block, a wooden sleeper or iron rod, should be suspended fore and aft by two pair of wires A B, A C, fastened to staples, A, on the top of the block, and splayed out; and then, to prevent racking action and to allow only the direct recoil motion, a fifth wire B D is fastened to a bar A D, levered out sideways, and weighted to give preponderance enough to keep all the wires at practically the same tension, as seen in the end view of Fig. 9—three wires in front, the other two behind.

In Bertram Hopkinson's experiments for determining the duration of impact of a bullet, the wooden sleeper is replaced by a steel cylindrical rod; and from a knowledge of the velocity of elastic longitudinal waves in the steel, about 17,000, f/s, the length of the rod could be adjusted so as to trap all the energy, and leave the rod in motion without internal vibration (*Phil. Trans.*, November, 1913).

Suppose the block or rod weighs W lb, and is free to recoil with each particle on a circle of radius l, and a bullet weighing w lb is fired direct at it with velocity v, f/s, and shattered by the impact.

The block recoils with equal momentum, but the velocity is diluted to V, such that if the static thrust of the blow is F lb acting for t seconds,

$$Ft = \text{W}\frac{\text{V}}{g} = w\frac{v}{g},\ \text{sec-lb.}$$

A point O on the block will recoil to A, a distance O A, where, as shown already,

$$\text{V} = n\,.\,\text{OA},\ v = \frac{\text{W}}{w}\,n\,.\,\text{OA},\ n = \sqrt{\frac{g}{l}}.$$

But as l is difficult to measure, it is inferred from the time T of a double beat of the pendulum; keeping the pendulum swinging by a timed push and counting the number N in a given interval, say 1 minute, and then

$$\frac{60}{\text{N}} = \text{T} = 2\pi\sqrt{\frac{l}{g}},\ \text{V} = \frac{2\pi}{\text{T}}\,\text{OA},\ v = \frac{\text{W}}{w}\,\frac{2\pi}{\text{T}}\,\text{OA}.$$

Thus a tape drawn out from O to A may be graduated uniformly to measure v, at a scale $\frac{w}{\text{W}}\frac{12\,\text{T}}{2\pi}$ in. per unit f/s of velocity of the bullet.

During the impact the block recoils with average velocity $\frac{1}{2}$V through a distance

$$\tfrac{1}{2}\text{V}t = \frac{\text{W}}{\text{F}}\cdot\frac{\text{V}^2}{2g} = \frac{\text{W}}{\text{F}}\cdot\frac{\text{O A}^2}{2l}.$$

In Hopkinson's experiment the bullet behaves as if plastic-fluid; the particles escaping sideways, and the bullet crushes up with average velocity $\frac{1}{2}(v + \text{V})$; and if the length of the bullet is b feet,

$$b = \tfrac{1}{2}(v + \text{V})t = \left(\frac{\text{W}}{w} + 1\right)\frac{\text{W}}{\text{F}}\cdot\frac{\text{V}^2}{2g} = \left(\frac{\text{W}}{w} + 1\right)\frac{\text{W}}{\text{F}}\,\frac{\text{O A}^2}{2l}$$

from which F is inferred,

$$\text{F} = \text{W}\left(\frac{\text{W}}{w} + 1\right)\frac{\text{O A}^2}{2bl}.$$

Replace the plastic bullet by another length of rod, in end contact, and suspended by equal five point suspension, for an experimental study of elastic impact of rods.

20. Suppose two such lengths, a and $n\,a$, of steel rod are mounted with equal five-point suspension in contact, end to end, and the length a is drawn

aside to impinge with velocity V. It will be reduced to rest by the impact, and the second bar will start to move by successive advances of the ends, in caterpillar action, with velocity V for intervals of time $2a/U$, and intervals of rest $2(n-1)a/V$, U denoting the velocity of the elastic longitudinal vibration in the rods (Thomson and Tait, "Natural Philosophy," sec. 304).

Thus if $n = 1$, the second rod takes up the velocity of the first, and the impact is as if perfectly elastic, between springs of no inertia.

A similar action can be observed in a train with spring couplings. Two or three empty carriages allowed to strike the terminal buffers at a platform are observed to rebound, and then strike again.

In a recent slight railway accident, where the train appeared to be slowing down too much to reach the terminals, the release of the engine brake made the head of the train appear to leap forward, the rear being retarded. The air brake was then applied too hard, the wheels skidded, and the train came bump into the buffer stops. In this case the retardation of the engine brake had caused the buffers to be compressed more and more towards the engine, and the release of the brake allowed a resilient elongation wave to ensue in the train.

With carriages of equal weight W, the preceding expression for the time of impact, compression and restitution becomes $t = \pi\sqrt{\left(\frac{a}{g}\frac{W}{F}\right)}$, so that, with carriages of length c feet, a longitudinal wave appears to travel along the train with velocity

$$\frac{c}{t} = \frac{c}{\pi}\sqrt{\left(\frac{g}{a}\frac{F}{W}\right)},$$

If the train in variable compression is assimilated to a continuous steel rod, compressed not uniformly but with intensity as the distance from the rear free end, the release will cause a wave to travel out of it, as if it met its inverted reflexion in the front end, wiping out the end thrust.

Similar considerations arise in the bore of a gun, with the axial variation of the pressure and density of the powder gas.

21. In shooting at a stout wooden block the bullet is embedded; and if it penetrates a feet against an average resistance R, lb, in a time t sec,

$$Rt = W\frac{V}{g} = w\frac{v-V}{g} = \frac{W\,w}{W+w}\,\frac{v}{g} = W\,\frac{2\pi\cdot OA}{gT}$$

Ra = K.E. liberated, as before in B, ft-lb,

$$= \frac{W\,w}{W+w}\,\frac{v^2}{2g} = \frac{W}{w}(W+w)\frac{V^2}{2g}$$

$$= \frac{W}{w}(W+w)\,\frac{O\,A^2}{2l} = \frac{W}{w}(W+w)\,\frac{2\pi^2\cdot OA^2}{gT^2}.$$

Then by division R is cancelled,

$$\frac{t}{a} = \frac{w}{W+w}\cdot\frac{T}{\pi\cdot OA},\quad \frac{t}{T} = \frac{w}{W+w}\cdot\frac{a}{\pi\cdot OA},$$

during which time t the block recoils, with average velocity $\frac{1}{2}V$, a distance

$$\tfrac{1}{2}Vt = \frac{W}{R}\cdot\frac{V^2}{2g} = \frac{wc}{W+w},\ \text{ft.}$$

Shooting a bullet up the bore of a rifle is this dynamical operation in reverse order, with a the travel of the bullet through the bore, v its muzzle velocity and V the velocity of recoil; thence R can be inferred, the average propelling thrust on the bullet and the effective pressure of the powder.

Denoting by W, B, P the weight of rifle, bullet and charge of powder, the rifle recoils as if let drop a height

$$H = \frac{V^2}{2g} = \left(\frac{B+cP}{W}\cdot\frac{v}{8}\right)^2\ \text{ft, taking } g = 32,\ f/s^2.$$

Here W, B, P, required to be specified in the same unit—pound, ounce, dram, grain, gram. But if, as usual, W is given in pounds, but B, P, in grains, the formula changes to

$$H = \left(\frac{B+cP}{7{,}000\,W}\cdot\frac{v}{8}\right)^2,\ \text{ft.}$$

The factor c is empirical, and depends on the nature of the powder in its blast of setting the air in motion near the muzzle. Each brand of powder requires its own c to be determined by experiment, and c may vary from 0·5 to 1·0 and over.

Thus, for example, in a service rifle, with W = 9lb, B = 215, P = 32 grains, and $c = 1{\cdot}125$, $cP = 36$, $B + cP = 252$ grains, $\frac{B+cP}{7{,}000\,W} = \frac{4}{1{,}000}$ and with V = 2,000, f/s, H = 1 ft. But if v is raised to 2,440, f/s, $H = (1{\cdot}22)^2$ ft, say, 18 in.

This theory will serve for showing off indoors the effect of the recoil, without firing off the rifle, but only letting it drop on the toes, from a height gradually increased. But the physical impression of recoil is unknown till the condition of surface is specified in contact with the butt of the rifle, such as the position in firing and the thickness of the coat. When it is asserted a gun kicks more in summer than winter, it implies that there is less thickness of coat as a cushion for the butt.

We read in "Aviation, 1917," of a 12-pdr gun, weighing 100 lb, fired from the shoulder, to be used up in the air on a flying machine or airship, a problem in invention, to design a non-recoil gun of that size. The gun must fire simultaneously a double charge, out at each end, to neutralise the momentum.

22. The above is the formula employed after the bullet has left the muzzle, but during the passage of the projectile up the bore of the gun, as in Fig. 10, the weight P of the charge of powder must be shared between the weight W of the gun, and w of the shot.

Fig. 9.

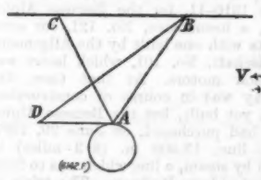
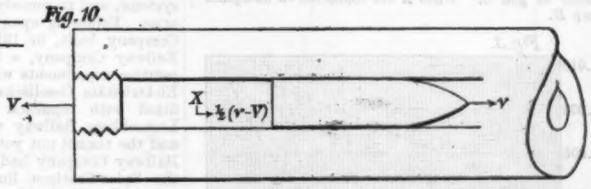


Fig. 10.



Reckoning W, w, P, all in tons for a large gun, and assuming the density of the powder gas uniform, the velocity of the centre of gravity of the charge is $\frac{1}{2}(v-V)$ forward, when the shot is advancing with velocity v, and the gun recoiling with velocity V.

Then if X is the average thrust in tons of the powder on the base of the bore, and Y on the base of the shot, during the t seconds of movement,

$$Xt = W\frac{V}{g},\ Yt = w,\ \frac{v}{g}\ (X-Y)t = P\frac{\frac{1}{2}(v-a)}{g},$$

$$(W+\tfrac{1}{2}P)V = (w+\tfrac{1}{2}P)v,\ \frac{V}{w+\frac{1}{2}P} = \frac{v}{W+\frac{1}{2}P};$$

true also for any variable X and Y; and if the gun has recoiled x feet while the shot has advanced y feet, a distance $x + y = l$ feet up the bore, in t seconds,

$$\frac{x}{w+\frac{1}{2}P} = \frac{y}{W+\frac{1}{2}P} = \frac{l}{W+w+P},\ t = \frac{2x}{V} = \frac{2y}{v} = \frac{2l}{v+V}$$

The average powder thrust, X tons on the base of the bore, Y tons on the base of the shot, is given by

$$X = W\frac{V^2}{2gx} = \frac{W+w+P}{w+\frac{1}{2}P}\ W\frac{V^2}{2gl},$$

$$Y = w\frac{v^2}{2gy} = \frac{W+w+P}{W+\frac{1}{2}P}\ w\frac{v^2}{2gl}$$

and X, Y, are divided by $\frac{1}{4}\pi d^2$ to give the powder pressure, in tons/in², for a calibre of d inches.

The gun must be made strong enough to resist the maximum powder pressure, so that the science of the powder maker is directed to keeping the pressure as uniform as possible; and then the gun maker can dispose of the metal to the best advantage, as in the ideal shape of a pea-shooter or pneumatic gun, instead of the chubby, corpulent shape, of the old muzzle-loading Woolwich infant.

23. If the thickness of the block is not enough to stop the bullet, but the block is perforated and the bullet passes out with velocity u,

$$Rt = W\frac{V}{g} = w\frac{v-u}{g},\ Ra = w\frac{v^2}{2g} - W\frac{V^2}{2g} - w\frac{u^2}{2g},$$

and R must be determined experimentally by measuring the penetration c of the bullet, fired into the block held fixed, so that $Rc = w\frac{v^2}{2g}$.

Then by the solution of these simultaneous equations a quadratic arises, and we find

$$\frac{u}{v} = \frac{w + W\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}}{W+w}$$

$$\frac{V}{v} = \frac{w - w\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}}{W+w}$$

$$u - V = v\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}$$

And we notice that V is small compared with v and u.

The average velocity of perforation being

$$\tfrac{1}{2}(v+u+V) = \tfrac{1}{2}v + \tfrac{1}{2}v\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}$$

the time of perforation is

$$\frac{2a}{v}\ \frac{1}{1+\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}}$$

$$= \frac{2c}{v}\ \frac{1-\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}}{\left(1+\frac{w}{W}\right)}$$

To interpret the second root of the quadratic, it corresponds to the case where the bullet was received in a prolongation of the block, and ejected again by the continuance of the resistance R; and then the equivalent of Newton's coefficient of restitution is

$$\sqrt{\left[1-\left(1+\frac{w}{W}\right)\frac{a}{c}\right]}.$$

It is asserted in Moseley's "Illustrations of Mechanics," 1839, that a tallow candle can be fired from a gun through a barn door. The incredulous experimenter found that a small bit of the candle did certainly find its way through, but he was bespattered by the rebound of the bulk of the tallow. So, too, in model armour plate experiments, imitated by firing a bullet through wet clay, it is prudent to keep a safe distance.

THE SOCIETY OF CHEMICAL INDUSTRY.—The medal of the Society of Chemical Industry for 1920 has been awarded to Monsieur Paul Kestner in recognition of his distinguished services to chemical industry. The medal is awarded biennially, and among the recipients in recent years have been the Right Hon. Sir Henry Roscoe (1914), Mr. C. F. Cross (1916), Sir James Dewar (1918). Monsieur Kestner was born in Alsace prior to the German occupation in 1871; he was one of the chief founders and the first president of the Société de Chimie Industrielle in France, which was established in 1917. He has been connected with engineering as applied to chemical industry throughout his career, and among his more notable achievements are the use of forced draught in acid towers, automatic acid elevators, the climbing film evaporator, the scaleless water-tube boiler, and several inventions in connection with beet sugar manufacture. Very shortly before the armistice, M. Kestner gave an address of great interest and importance to the London Section of the Society on "The Alsace Potash Deposits and their Economic Significance in Relation to Terms of Peace."

DEVELOPMENT OF THE HOLZWARTH GAS TURBINE.—Experiments with the 1,000-h.p. gas turbine of Holzwarth, built by Thyssen and Co., of Mülheim, were interrupted by the war and only resumed in 1918. But the research was not stopped, and last December Holzwarth was able to conduct some trials in the presence of railway engineers from Berlin, in which about one-third of the theoretically realisable heat energy seems to have been utilised; the fuel was coke-oven gas (*Zeitschrift des Vereines Deutscher Ingenieure*, February 28 last). The turbine was of the vertical type; a horizontal arrangement is in future to be adopted. In the researches the explosion pressure has been raised up to 12 and 14 atmospheres absolute, while the expansion period has, in order to reduce heat losses, been reduced to 0·1 second—which is short for a gas engine, but still long by comparison with an aeroplane motor. The construction of the blades had to be altered materially to stand the explosion pressures. The blades are made each in one piece like a Laval blade, and the material selected after many trials, is a soft electrolytic iron, tested at 450 deg. C.; various alloy steels did not answer, whilst the new blades look perfect after several months service. The nozzles are nearly cylindrical as in Laval turbines; the valves required modification.

ONE-PIECE GUN CONSTRUCTION.

IN a paper recently read before the American Institute of Mining and Metallurgy, Professor P. W. Bridgman, of Harvard, who is famous for his experiments on water and other bodies under extremely high pressures, described an experiment in one-piece gun construction carried out under his direction by the Naval Authorities of the United States. The gun in question had an internal diameter of 3 in.; it was 23 calibres in length, and was made from a single forging. Were the mathematical theory of elasticity directly applicable to gun stresses such a single piece gun should be very

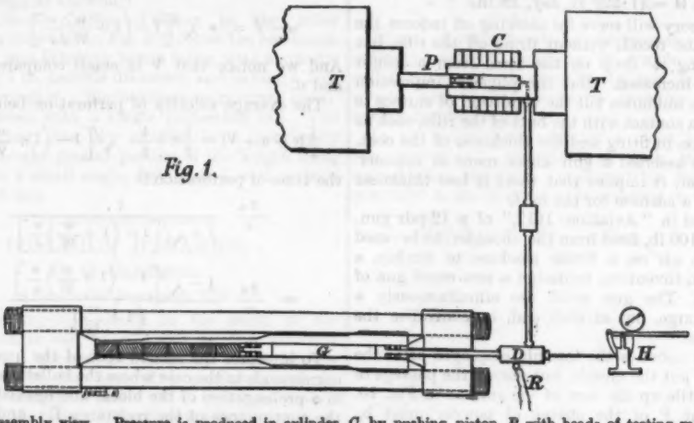


Fig. 1.

General assembly view. Pressure is produced in cylinder *C* by pushing piston *P* with heads of testing machine *T*. Pressure is transmitted through connecting pipes to interior of gun *G*. Wires *R* are connected to manganin resistance cage. Initial pressure is produced by hand pump *H*.

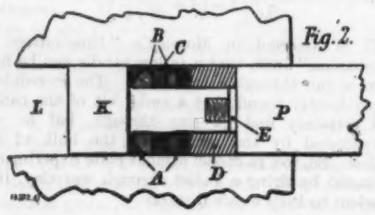


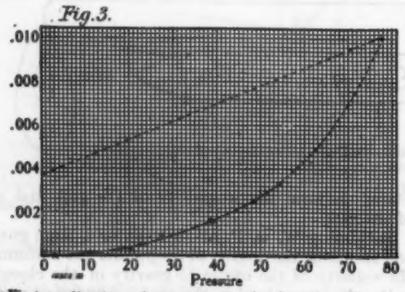
Fig. 2.

Details of packing plug of cylinder. Piston *P* pushes plug toward liquid at *L*. *A* is soft steel, *B* solder, *C* soft rubber, *D* hardened steel. *E* is unsupported area back of the plug.

much weaker than a built-up or wire wound gun, but as is well known the elastic limit of a material frequently constitutes in practice but a very indifferent criterion of strength. By giving a cylinder an initial stretch before employing it in service its strength can be very greatly increased. This has long been known, and Professor Bridgman notes that the Austrians, so far back as the eighteenth century, attempted to increase the practical strength of their guns by forcing an expanding steel mandrel through the bore. In the United States Navy experiments, the stretching was effected by hydraulic pressure, the arrangement being as illustrated diagrammatically in Fig. 1. Here the gun is represented at G. The length of the bore under treatment is plugged by packings, the construction of which resembles that illustrated in Fig. 2, which will be described later on. A small hand pump H was used for filling the gun and raising the pressure up about 20,000 lb. per square inch, and this pressure was subsequently raised to over 90,000 lb. per square inch by means of an augmenter consisting of a cylinder C and a plunger P placed between the platens of a large testing machine. The fluid used for transmitting the pressure was kerosene. Other fluids are liable to give trouble by solidifying under extreme pressures. The intensity of the pressure was measured by the change in the resistance of a coil of manganese wire immersed in the fluid.

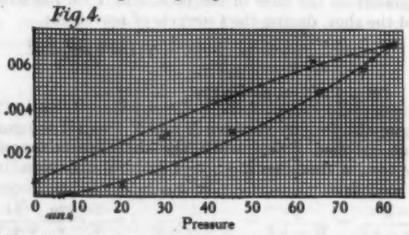
The plunger P of the augmenter was of glass hard tool steel, and the joint between it and the cylinder C was made tight by the packing illustrated in Fig. 2. This packing it will be seen consists of a plug K with a stem of smaller diameter. Around the stem are placed the packing rings. Of these those lettered A are of soft steel, whilst B and B denote rings of solder and C a ring of ordinary soft rubber, whilst D is a ring of hardened steel. The end of the stem of the plug K is cut off so as to leave a clear space between it and the end of the plunger P, thus providing for the compression of the packing as the pressure rises. The packing is, it is stated, tight under extreme pressures, but its friction is considerable. During the process of applying hydraulic pressure the increase in the outer diameter of the gun was measured at intervals and these strains were then plotted against the corresponding pressure as indicated in Fig. 3. On a first application of the pressure there was, as will be seen, no proportionality between

Fig. 3.



First application of pressure to the breech. The increase of outside diameter (ordinate) is shown in inches against the internal pressure (abscissa) in thousands of pounds per square inch.

Fig. 4.



Fourth application of pressure to the breech. The increase of outside diameter (ordinate) is shown in inches against the internal pressure in thousands of pounds per square inch.

stress and strain, but after repeated applications approximate proportionality is attained as will be seen from Fig. 4. Here the points observed during the release of the pressure lie approximately on a straight line.

The deviations from the straight line law are attributed to initial stresses in the forging which can only be eliminated by repeated applications of high pressures. After this hydraulic treatment the gun was finished and tested with proof charges, the results being highly satisfactory. Nine rounds were fired with charges developing a pressure of 21·8 tons per square inch, the service pressure being 13 tons per square inch. As already mentioned, the process is not new, and in our issue of March 12, 1915, page 306, Professor John Perry described a very similar series of experiments made under his direction first at Elswick and later elsewhere. Here, as in Professor Bridgman's experiments, the cylinder under treatment had a bore of 3 in. Its external diameter was 10 in. and it was subjected to gradually increasing hydraulic pressures up to 40 tons per square inch and withstood subsequently the firing of a charge inside it developing a pressure of 52 tons per square inch.

During the hydraulic treatment the cylinder was heated by gas jets to such a temperature as to prevent the metal hardening under plastic flow. Moreover, Professor Perry gave a theory of the resistance of such cylinders by which he claims that it is possible to calculate beforehand their strength under internal pressure. For this we must refer our readers to his article *loc. cit. supra*, but the interesting point comes out that according to his theory its tensile stress is highest at the exterior surface of the cylinder. On the ordinary elastic theory the tensile stress is highest at the internal surface, but as a matter of fact thick cylinders under pressure never do fail at the inner surface but always at the outer.

CITRÖEN GEAR FOR ELECTRIC LOCOMOTIVES.

THE Oerlikon Works Company introduced, a few years ago, an alternating-current, single-phase, series traction motor, designed by Dr. Behn Eschenburg and Engineer Schirlin. A first trial of a low power locomotive fitted with two 250-h.p. motors of this type was carried out in 1907, on the Seebach-Wettingen line, near Zurich, with a view to ascertaining the behaviour in actual working conditions of the type of motor, what influence, if any, the operation of a line on single-phase high-pressure (15,000 volts) currents and low frequency (15 periods) might have on the neighbouring telegraph and telephone systems, and to remedy any inconvenience that might arise. Following upon a series of trials, the Oerlikon Company built, in 1910–11, for the Bernese Alpine Railway Company, a locomotive, No. 121, for competitive experiments with one built by the Allgemeine Elektricitäts Gesellschaft, No. 101, which latter was fitted with repulsion motors. At that time, the Loetschberg Railway was in course of construction, and the tunnel not yet built, but the Bernese Alpine Railway Company had purchased, on June 29, 1907, the Spiez-Frütigen line, 13,500 m. (8·3 miles) in length, then worked by steam, a line which was to form a section of the Loetschberg Railway. The trials of the two locomotives were appointed to be run on this section, the final electric equipment of which was therefore carried out, the current supply being taken from the power station at Spiez. The locomotive in question of the Oerlikon Company, had two motor bogies, each one having three driving axles all connected by coupling rods to a common intermediate shaft which was driven by Citröen gear. It was in view of this trial locomotive that the problem of gear transmission was referred to the Citröen Gear Company by the Oerlikon Company. The results were satisfactory from every point of view, and compared most favourably with those given by the German locomotive; this latter had to be set aside before even it had undergone the full series of trials, for though it had no gear transmission, its efficiency was far below that of the Oerlikon locomotive. Further, the current required by its repulsion motors on starting was so large that it greatly interfered with the smooth running of the power stations.

Following upon these trials, the Oerlikon Company designed, towards the end of 1911 and in agreement with Mr. Thomann, chief engineer of the Loetschberg Railway, a new type of locomotive having five driving axles, two motors, two transmissions by gearing and coupling rods, and two carrying axles, a certain number of which engines were built for the regular service of the railway, both by the Oerlikon Company and Messrs. Brown, Boveri and Co. All the gearing for these engines, 14 in number, numbered 151 to 164, was manufactured by the Citröen Gear Company. During the war, other locomotives were ordered by the railway company, but owing to their war work for the French Government, the Citröen Gear Company was unable to supply the gears for these other units; the required gearing was accordingly manufactured by a German company who had, two years previous to the war, acquired a licence from the Citröen Company and who, after the recission of the contract continued, notwithstanding, the manufacture of the gearing.

With respect to the trial locomotive No. 121 above referred to, which was described by the *Elektrotechnische Zeitschrift*, and in a pamphlet by Mr. Thomann, the power to be transmitted by gearing was 1,000 brake horse-power at speeds of 550 r.p.m. and 169 r.p.m., corresponding to a travelling speed of 42 km. (26 miles)

per hour, with wheels 1·300 m. (4 ft. 3¼ in.) in diameter, the maximum speed being 920 revolutions at the motor and 70 km. (43·5 miles) per hour on the track. The gearing had the following dimensions :—

	Pitch circle diameter.	
	447·04 mm. = 1 ft. 5⅝ in.	1,452·96 mm. = 4 ft. 9⅛ in
Number of teeth ..	32	104
Diametral pitch ..	18·970 mm.	
Width	250 mm. = 9¹³/₁₆ in.	

In this engine the pinion is keyed on the rotor shaft and the wheel on the intermediate shaft which is fitted with the two crankplates. The pinion is of forged steel having a tensile strength of 70 kg. to 75 kg. per square millimetre (44·44 tons to 47·62 tons per square inch) and 12 per cent. to 14 per cent. elongation; the wheel consists of a forged steel rim having 60 kg. to 65 kg. (38·09 tons to 41·27 tons per square inch) tensile strength and 16 per cent. elongation, shrunk on a centre cast in steel, the latter being pressed on the intermediate shaft. The peripheral speed at the teeth is therefore 12·84 m. (42 ft. 1¼ in.) per second at the normal travelling speed of 42 km. per hour and 21·40 m. (70 ft. 2¼ in.) per second at the maximum travelling speed.

The locomotive No. 121, put on the line in 1911, is still in service. During the trials on the Spiez-Frütingen line, the speed did not exceed 40 km. (24·8 miles) per hour, since the track was built with comparatively light rails; the line was put down as a secondary line, for steam traction, and was maintained as such for a certain time after the opening of the complete railway, the other portion of which was built with rails of heavier section. Independent tests, however, were also made at a speed up to 70 km. (43·5 miles) per hour. The gearing had always acted satisfactorily, and the only trouble which occurred had reference to a certain difficulty of running round curves when the speed was between 40 km. and 70 km. (24·8 miles and 43·5 miles) per hour, a difficulty which is easily explained, seeing that on each bogie, the greater mass of the motor on each particular bogie is outside the bogie pivot with reference to the centre of the machine. The mass of the motor had a tendency to maintain the bogie in a line following the tangent to the curve, instead of tending to trim it for guiding it in the curve.

On the locomotives Nos. 151 to 164, the power to be transmitted is 1,250 brake horse-power for each set of gearing, at the speeds of 450 r.p.m. and 202 r.p.m., corresponding to 50 km. (31 miles) per hour, the wheels being 1·350 m. (4 ft. 5 in.) in diameter on the tread; the maximum speed is 630 revolutions for the motor and 70 km. (43·5 miles) on the track. The gearing is of the following dimensions :—

	Pitch circle diameter.	
	668·569 = 2 ft. 2⅛ in.	1,491·423 = 4 ft. 11¼ in.
Number of teeth ..	52	116
Modulus	12·8571	
Width	250 mm. = 9¹³/₁₆ in.	

These gears were built exactly like those for the locomotive No. 121, and of the same materials. The trials of the latter locomotives took place in June, 1913, on the completed railway, and they were continued in actual service during all the summer, as each locomotive was delivered at Spiez. The trials showed that the working of the gears was perfect, their efficiency being at least as high as that of the locomotive No. 121. But the actual service being that of an international railway, the commercial speed attained 50 km. (31 miles) per hour, notwithstanding the rather heavy gradients, and the maximum speed was maintained at 70 km. (43·5 miles) per hour.

Fig. 1.

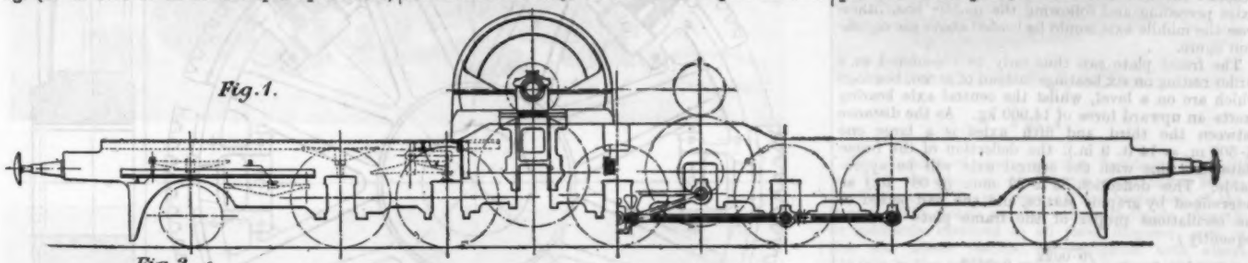
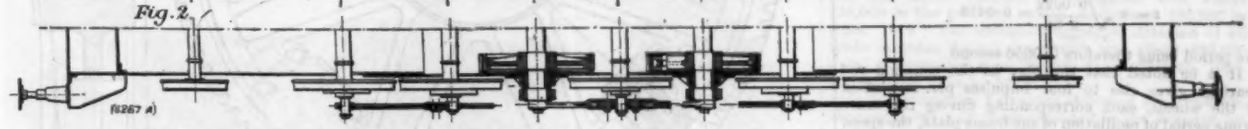
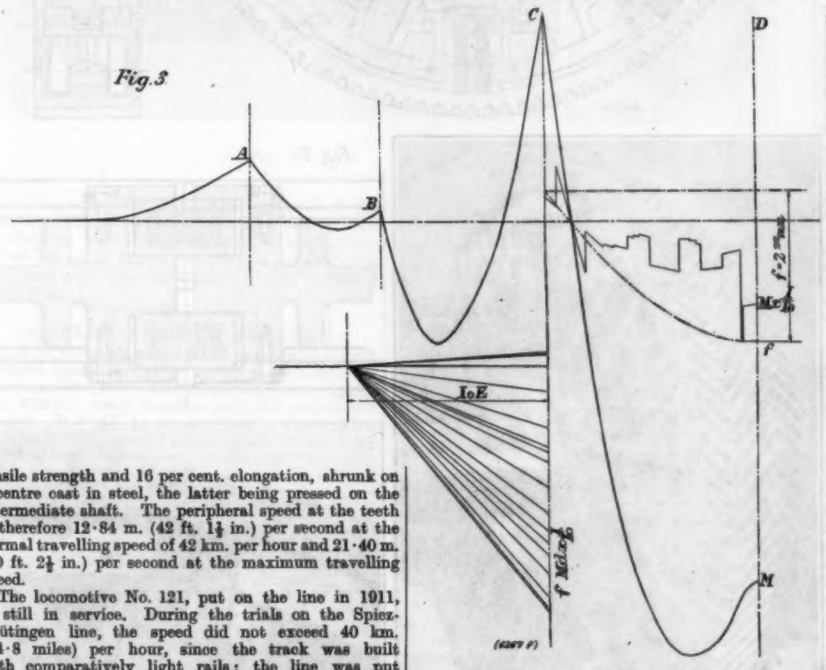


Fig. 2.



(5267 A)

Fig. 3.



It was under these conditions that a somewhat strange phenomenon was noticed; rather heavy vibrations occurred when the speed was between 39·5 km. and 40 km. (24·5 miles and 24·8 miles) per hour, they reached their maximum between 40 km. and 41 km. (24·8 miles and 25·4 miles) and disappeared when the speed was between 41 km. and 41·5 km. (25·4 miles and 25·7 miles) per hour, and did not reappear at speeds above the latter figure. The same phenomenon occurred during slowing down, and was maintained so long as the speed remained between 39·5 km. and 41·5 km. (24·5 miles and 25·7 miles).

The trouble at first was thought to be due to an inaccurate division of the teeth, but such a supposition was inadmissible, for had that been the case the oscillations would have increased between the speeds of 41 km. and 70 km. in proportion to the square of the speed. Following this, experiments were carried out by engineers of the Citröen Gear Company in November, 1913, using the Auclair absolute accelerometer, an instrument which allowed of measuring at the axle-boxes, vertical accelerations up to 80 m. to 85 m. per second, equal to nine times the acceleration of gravity. The vibrations were so serious that they led in some instances to fracture of the coupling rods; these latter were subsequently strengthened. The reason for the vibrations, which arose no doubt through resonance, could not be directly deduced from the trials, and for some time the question greatly puzzled the engineers in charge. One of the causes of the resonance phenomenon had certainly to be looked for in the inevitable play of the crank-pin and coupling-rod bearings, a play which has long caused trouble in the case of steam locomotives and requires careful attention. The play in the bearings, when it exists, has in itself an influence which is constant and is independent of the speed; this influence becomes serious only when it is amplified by resonance, i.e., when another, periodical cause is added to the first. This second cause, by the very nature of the phenomenon, has a fixed, invariable period, which corresponds precisely to the speed of 40 km. to 41 km. per hour; it is of a necessity a pendular oscillation of duration $t = \pi\sqrt{\frac{f}{g}}$, where f is the elastic deflection, under the influence of a fixed load, in a mechanical part which is liable to vibrate. The mechanical part in question remained to be found. Mr. Buchli, in the course of an article which appeared in the spring of 1914, and was based upon some laboratory tests, states that the elastic torsion of the motor shafts, axles and intermediate shaft comes into play.

In order to get rid of these oscillations, it was decided in December, 1913, to make a trial with elastic gear wheels, namely, wheels having a rim capable of rotating slightly round their centres, the extent of the rotation being controlled by springs. The Citroen Gear Company built two such experimental wheels constructed as illustrated in Figs. 4 and 6. The arrangement of the springs in the wheel centre is such that all the spring plates are effective for each direction of rotation, whilst in most of the devices formerly designed for the same purpose a separate set of springs was provided for each direction of motion, or else the springs had to be fitted under an initial tension of half the maximum required, which latter condition led to difficulties in the fitting of the springs in the first instance. Two elastic gear wheels were provided for one locomotive, in case the tests showed that one alone did not suffice. The tests, however, demonstrated that the use of one elastic wheel of the two which form part of the gearing for each locomotive sufficed to do away with the oscillations at speeds between 40 km. and 41 km. The trials proved, therefore, that the trouble could be traced to the rigid connection by means of gearing of both the rotors with the transmission mechanism and that the rigid connection could be maintained in the case of one of the two rotors. The two rotors, it is true, have a high inertia, but if it had been necessary to consider this inertia as intervening alone, the phenomenon would have occurred not at one clearly defined speed only but over a somewhat wide range of speeds.

The distribution of the axle loads on the locomotives is somewhat peculiar.

The load is distributed on the axles by means of equalisers, as in the case of steam locomotives. The locomotive complete weighs in running order 108·6 metrical tons; the five central pairs of wheels and axles weighing each 2,040 kg., and the two end ones 1,530 kg. each, whilst the suspended load is 95,340 kg. On the other hand, the maximum designed load on a driving axle is 17,000 kg.; on this basis, and reckoning, further on a maximum load of 11,800 kg. for each end axle, the suspended load does not exceed 14,960 kg. for each of the five driving axles and 10,270 kg. for each of the two end axles. But the weight of a complete

motor is made up as follows: Rotor, 4,715 kg.; pinion, 449 kg.; shaft, 459 kg.; stator, 5,715 kg.; intermediate shaft and toothed wheel, 2,410 kg.; crank-plates, 400 kg.; making up a total of 15,150 kg. in round numbers. Since half the weight of each of the two motors is taken by the middle axle; as also a part of the weight of the frame plates and body it is clear that the load over this middle axle must be in excess of that authorised by the regulations, so long as the rigidity of the frame is insufficient to transfer part of this load to the other axles, since the central load is distributed solely by special springs on the corresponding axle, without an equaliser. Consequently, if the conditions under which the frame plates undergo flexion be gone into by using the Clapeyron formula, it is necessary to take into account the flexion of the frame plate between the axles preceding and following the middle one, otherwise the middle axle would be loaded above the regulation figure.

The frame plate can thus only be considered as a girder resting on six bearings instead of seven, bearings which are on a level, whilst the central axle bearing exerts an upward force of 14,960 kg. As the distance between the third and fifth axles is a large one (4·500 m. = 14 ft. 9 in.), the deflection of the frame plate in a line with the central axle will be appreciable. This deflection is 2·22 mm. (0·087 in.) as determined by graphic statics, and the half-period of the oscillations proper of the frame plate is consequently:

$$t = \pi \sqrt{\frac{0{\cdot}0022}{9{\cdot}81}} = 0{\cdot}0478$$

the period being therefore 0·0956 second.

If it be noted that the play in the coupling rod bearings gives rise to four impulses per revolution of the wheels, each corresponding during resonance to one period of oscillation of the frame plate, the speed at which resonance occurs must be $\frac{1}{0{\cdot}0956 \times 4} = 2{\cdot}615$ revolutions per second, and as the wheels are 1·350 m. in diameter at the tread, the corresponding travelling speed is that of 40 km. per hour.

In the course of the experiments made in November, 1913, using the accelerometer, the engineers in charge were able to note a variation in the distance between the two motor centres of about 5 mm. to 6 mm. (0·196 in. to 0·236 in.) during the period of oscillations, which proves, the motors being fixed to the frame plate, that the latter was in vibration, the loops in the curves corresponding with the middle of the locomotive the nodes coming above the third and fifth axles.

It is quite clear that if the grouping of the machinery had made it possible, it would have been preferable to have recourse to equalisers so as to distribute a part of the central load to the other axles, and without making any call on the flexure of the frame plates; this would have decreased the deflection of the latter to a value sufficiently low for resonance to occur only at a travelling speed above 70 km. per hour. There was, however, not sufficient room for such equalisers. Further, if the moment of inertia of the frame plate could have been increased sufficiently, the central deflection could also have been decreased and the danger of resonance limited to speeds above 70 km., this would, however, have resulted in an increase of weight such that the load per axle would have exceeded the permissible limit.

The motors being fitted to the frame plate, the masses of the rotors tend during the vibrations to have a pendular movement round a centre of rotation and tend simultaneously to approach and to withdraw from each other in revolving round the centre of the intermediate shafts. But these actions can only occur by the rotation of the pinion and wheel round their respective centres. At a given moment during a vibration, this motion, in the case of one rotor tends to add itself to the normal rotating action, whilst it tends to act in the reverse way as regards the second rotor. The inertia of the rotors therefore intervenes, for it may come in at the instant a crank arrives at the dead point of the transmission by the oblique coupling rods, an instant which does not correspond with the dead point of the transmission of the second rotor, and this inertia during a very short interval develops considerable stresses in a direction tangent to the teeth, efforts which are not transformed in a useful torque, but only into a flexion torque of the frame plate, through the bearings of the intermediate shafts.

Figs. 1 and 2 show the essential parts of the frame plate and transmission; from this it will be seen that the frame plate is not supported directly on the axles, but at the points of attachment to the frame plate of the equalisers, these being the points A, B, C and the symmetrical points relatively to the centre. Fig. 3 represents diagrammatically the flexure of the frame plate; the diagram applies only to the half of the central span C D, the other half being symmetrical relatively to D. The first curve, marked M, is that of the bending moments M; it is deduced from the loading by means of the Clapeyron formula. At D a force is supposed to act upwards, equal to the value of the load suspended at that point, and obtained by adjusting the springs. Since the moment of inertia of the frame plate varies with its constitution, the diagram of the reduced bending moments has been traced for the section C D, this diagram being no other than that M multiplied by the ratio $\frac{I}{I_0}$ of the local moment of inertia to a particular moment of inertia I_0 taken as unity. The values of $\int d\,M\,\frac{I}{I_0}$ on each portion of the diagram of $M\,\frac{I}{I_0}$ have been determined in sections, so as to obtain a series having the polar distance I_0 E which has served to trace the deflection curve f, by connecting by parallels to the radii of the series the verticals from the centres of gravity of each succeeding element of $fd\,M\,\frac{I}{I_0}$. There is thus found at D a deflection of 2·22 mm. (0·087 in.).

The engineers at first thought that the introduction of the elastic system, which is illustrated in Figs. 4 to 7, in one only of the two toothed wheels had sufficed to do away with violent vibrations, because the plate springs absorbed the energy developed by the inertia of one rotor and thus doubled the period of the oscillations. They also thought that the locomotives provided with one elastic wheel only would show trepidations solely at a travelling speed of 79 km. to 81 km. per hour, a speed which was never attained. They, however, soon realised that such was not the case, since the period of impulsions being doubled by the adoption of one elastic device alone

Fig. 4.

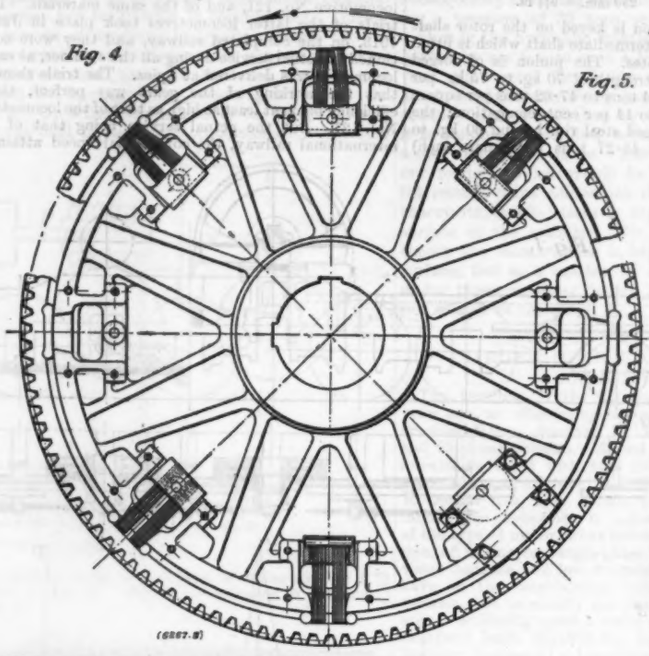


Fig. 5.

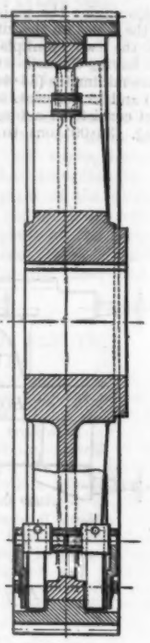


FIG. 6.

Fig. 7.

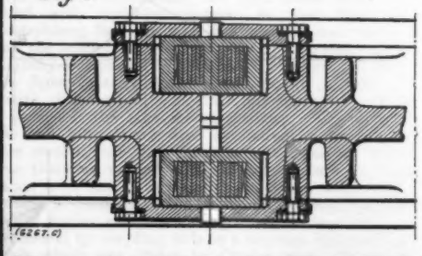


FIG. 8.

SKEFKO BALL BEARING HUB FOR ROAD VEHICLES.

CONSTRUCTED BY THE SKEFKO BALL BEARING COMPANY, LIMITED, ENGINEERS, LUTON.

FIG. 1.

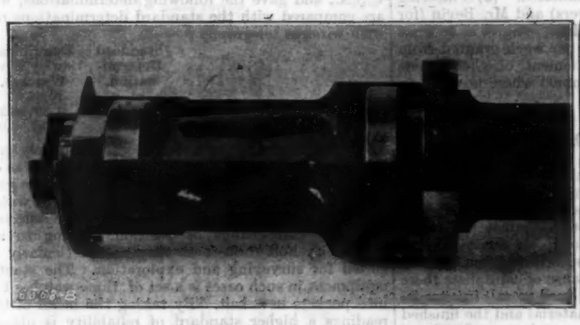


FIG. 2.

FIG. 3.

it is always greater than that of the vibrations of the frame plate. Therefore, with one elastic device alone the vibrations would reappear, but at a travelling speed as low as 20 km. (12·4 miles) if the deflection of the frame plate was quadrupled, which cannot of course occur.

SKEFKO BALL HUB BEARING

WHILE in the engineering world ball bearings have supplanted plain bearings in a very large number of types of machine, it is rather surprising that on horse-drawn vehicles plain bearings are still universally employed. It would be no easy task to discover the date of the last successful improvement in this direction, for though ball bearing applications have more than once been attempted, failure has usually resulted from the use of bearings of insufficient load capacity for the purpose. The Skefko Ball Bearing Company, of Luton, Beds., have for some time been experimenting in the manufacture of a ball bearing hub for horse-drawn vehicles, and have recently placed such a device on the market. Ample allowance is claimed to have been made for the stresses which occur in the hubs of heavily-loaded vehicles in motion.

The hub consists of a housing of cast-iron, which follows standard design in the matter of the wings or webs which grip the wooden nave of the wheel. In this housing are mounted two ball bearings, the inner of which is a single row annular bearing, designed to take the thrust loads which occur while the wheel is in motion. The outer bearing is a double row self-aligning bearing, which takes the main radial load. The bearings are kept at a fixed distance apart by a cast-iron distance sleeve, the outer bearing being fixed in position by a nut which screws on the end of the journal, locked by a cotter pin. The inner bearing is secured by a threaded sleeve with set screws. The housing is closed at the outer end by a flanged brass cover, while at the inner end an oil-saturated felt ring closes the space between the housing and the flange on the axle. When assembled, the hub is thus proof against dust and grit, and leakage of lubricant is prevented. Various views of a hub bearing in section and dissembled are given in our illustrations, Figs. 1-4, from which the construction will be clear with the foregoing description.

Tests of this hub have been carried out in the laboratory and on the road, and the results obtained would seem to show that the hub, apart from its obvious advantages over the plain variety, is capable of giving good service under as heavy loads as would ordinarily occur in use. In one of the laboratory tests a hub was run for 56 hours at 1,000 r.p.m. The load for the first 12 hours was 10 tons the sq. in., increasing by 1½ tons every 12 hours. Bearings which are capable of withstanding such a test as this have obviously a wide margin of safety when applied to even the heaviest types of horse-drawn vehicles. Another test was carried out with two similar vehicles of identical weight, one of which was fitted with the ball hubs. It was found in a trial that a man could draw a 64 per cent. greater load in the ball bearing hubbed vehicle than in the other. Part of this difference is probably due to the failure of plain bearings to retain lubricant when standing idle under load, and the consequent excessive friction during the first two or three revolutions. Ball hubs should be a great deal easier on horses. From this test and others carried out under the supervision of Mr. C. Herbert Sheather, F.R.C.V.S., Chief Veterinary Surgeon to the Hackney Horse Society, it would seem that when these hubs are fitted, loads can be increased by about 30 per cent. without increasing the demand on the horse, of course on the level.

A considerable economy of lubricant is also effected, the saving being actually between 80 per cent. and 90 per cent. of the lubricant used with plain bearings. The design of the hubs makes it possible to mount them with equal facility in old wheels or new, and they are manufactured in several sizes, suitable for almost every type of horse-drawn vehicle.

INDUSTRIAL NOTES.

THE Ministry of Labour state that employment continued good on the whole in April, and was slightly better than in March. The percentage unemployed among workpeople (skilled and unskilled) in industries covered by the Unemployment Insurance Acts fell from 3·63 on March 26 to 2·80 on April 30, and the percentage unemployed among the members of certain trade unions (mainly of skilled workmen) from which statistics are obtained declined from 1·1 to 0·9. The number of men and women on the live registers of the Employment Exchanges fell from 337,854 on April 1, to 325,915 on April 30. The improvement in employment indicated by the foregoing figures was mainly due to the reduction in the number of unemployed in the engineering trades and, to a smaller extent, in the building trades, in which very few skilled men are now unemployed. In other trades the position was usually about the same in April as in March.

FIG. 4.

The number of trade disputes beginning in April was 134. In addition, 84 disputes which began before April were still in progress at the beginning of the month. The total number of workpeople directly or indirectly involved in all these disputes, new or old, was about 140,000, as compared with about 134,000 in the previous month, and about 106,000 in April, 1919. The estimated aggregate duration of all trade disputes during the month was about 880,000 days, as compared with 788,000 days in March, 1920, and 473,000 days in April 1919.

In the industries for which statistics are available, changes in rates of wages reported to the Department as having been arranged to come into operation in April, with effect from that month, or from earlier dates, resulted in a total increase of 1,200,000*l.* in the weekly wages of 3,750,000 workpeople. The mining, metal and transport groups of trades accounted for 3,250,000 of this total, increases being given, under national arrangements, to coal miners engineers and shipbuilders, railway traffic workers and carters. In addition, the minimum rates of wages of agricultural labourers were raised in England and Wales and in Ireland. Changes in hours of labour affected over 14,000 workpeople, whose normal weekly working time was reduced by an average of nearly 4½ hours.

The general level of retail prices (including food, clothing, fuel and light, &c., as well as rents) on May 1 was about 141 per cent. above the level of July, 1914, taking the same quantities and, so far as possible, the same qualities of each article at the present time as before the war.

On July 21 an exhibition, run entirely by ex-service disabled men, is to be opened at the Central Hall, Westminster, to which the public will be admitted until the 29th of that month. Amongst the trades represented will be boot-making, watch and clock repairing, basket-making, tailoring, hairdressing, the building trades, including masonry and ornamental plaster work, the furniture trades, engineering, jewellery, &c. It is hoped that Lady Carnarvon's Therapeutic Society may supply a choir composed of disabled men who are pursuing a cure for stammering, and that bands composed entirely of disabled men will be sent by some of their associations. The exhibition—to which a small entrance fee will be charged—will be open daily from 11 a.m. to 9 p.m.

The National Health Insurance Bill, which has just received the Royal assent, makes important changes in the benefits and contributions under the Health Insurance Scheme to operate from July 5 next. The object of the changes is to provide for an increase in the rates of benefits in view of the fall in the value of money. The normal rate of sickness benefit will be raised from 10*s.* to 15*s.* a week in the case of men and from 7*s.* 6*d.* to 12*s.* a week in the case of women; disablement benefit will be raised from 5*s.* a week to 7*s.* 6*d.* for both men and women; and the amount of maternity benefit will be raised from 30*s.* to 40*s.* In order to provide for the increase of benefits the joint weekly contribution is to be increased from 7*d.* to 10*d.* in the case of men and from 6*d.* to 9*d.* in the case of women, of which the employer's portion will normally be 5*d.* in each case. In certain instances where low wages are paid the employer will be charged with a larger and the worker with a smaller portion of the joint contribution. The contribution cards from the week beginning July 5 next must in all cases be stamped at the rate of 10*d.* a week for men and 9*d.* for women; stamps of these values will be on sale at Post Offices.

The railway workers are now entitled under the sliding scale agreement to a further advance in wages

of 2s. per week. The sliding scale agreement provided for an increase of 1s. per week for each 5 points rise in the cost of living above 125 per cent. on the pre-war figure. At the first adjustment, when prices were 131 per cent. over the standard, an advance of 1s. per week was granted. With the new figure of 141 per cent. the railwaymen become entitled to a further advance of 2s.

Last week, the National Wages Board for the Railways considered the claim put forward by the National Union of Railwaymen for an advance of 1l. per week for all grades, and the claim of the Associated Society of Locomotive Engineers and Firemen of a daily wage for drivers of 1l., for firemen of 15s., for cleaners over 18 of 10s., for cleaners under 18 of 5s. and for motormen of 1l. In the course of the debates, Mr. R. Cope, chief accountant of the Great Western Railway, and a member of the Railway Accountant Committee, stated that the total annual railway wages now stood at 100,000,000l. over the figure for 1913, when the total bill was 47,000,000l. If the above claims were conceded, there would be a further sum of 35,000,000l. added to the bill per annum, and the railways of the country would be faced with a deficit of 79,500,000l. Mr. S. A. Parnwell, of the Committee of General Management of Railways, said the case of the dockers' increase had been frequently mentioned, and comparisons made to show that the railwaymen were much underpaid. He asked the court to say that there was very little comparison possible between the railwayman, with his guaranteed week and holidays paid for, and the docker who never knew whether he was going to enter the dock gates to begin a day's work until he actually did so. It was pointed out at further meetings that the only way of facing the situation created by granting the men's claims would be by another increase of 20 per cent. in passenger and goods rates.

Dr. Addison, Minister of Health, in reply to a question in Parliament on the 20th inst., said he had been informed that some bricklayers engaged on a housing scheme at Hayes had demanded that the contractors should dismiss one of their foremen and that, when pressed for the cause of the demand, the only substantial reason they could allege was that this particular foreman's section was laying a larger number of bricks than the others. The contractors refused to dismiss the foreman on this ground, and the protesting bricklayers left their job. He understood that some of the men of this foreman's section were said to be laying on an average 700 bricks a day, compared with 350 laid by other sections, and that there was no allegation that the men who were laying the larger number of bricks were being unduly pressed. The headquarters of the trade union had given no countenance to the men's action. He was also informed that the men had previously threatened to leave their job unless the building of certain concrete cottages was stopped. They subsequently withdrew from this attitude on the action of the headquarters of their union.

A meeting of the executive committee of the Miners' Federation was held last week at Southport, when the decision of the Government to increase the price of coal by 14s. 2d. per ton for domestic coal and 4s. 2d. per ton for industrial coal was considered. It was stated that the Miners' Federation had repeatedly urged upon the Government the necessity of keeping the prices of coal down, and that the industry was paying its way even to the extent of meeting recent increases in wages. The Executive Committee therefore deemed it necessary to convene a special conference of the Federation to be held in London on June 10 to consider the relations of wages to the increased income of the industry, and to the latest increase in the cost of living, as shown by the Government returns.

The question of the 44-hour working week was considered at the conference of the Federation of Engineering and Shipbuilding Trades which was held last week at Plymouth. Dissatisfaction was expressed at the delay of the employers in not proceeding with the inquiry on the question of hours as jointly agreed upon. It was decided to recommend that the inquiry be abandoned, and that a meeting of the Federation and other trades affected should be held within a fortnight to decide a further course of action.

Another decision was to recommend affiliated executives to either rigidly limit or stop overtime altogether until the 44-hour week is conceded. The next conference will be held at Scarborough.

All the London printing trade unions were represented by their executives at a meeting held in London on the 20th inst. Certain national unions were also represented. The following official statement was subsequently issued: "After a discussion lasting over 2 hours it was decided to accept an invitation received from the executive of the National Printing and Kindred Trades Federation to merge the London demand into those of the rest of the printing trade unions, and so consolidate the various applications, ranging from 15s. to 30s., now before the employers. Several national unions have yet to be consulted, but it is anticipated that future negotiations will be carried through in a national all-in policy by the executive of the National Federation."

A conference was held last week in London to deal with the Midland Canal strike. It was called on the initiative of the Transport Workers' Federation, who expressed their willingness to meet the employers. The following terms were arrived at and they have since been accepted by the men: (1) A Wages Board to be established with provisions for dealing with differences on the lines of the Midland Iron and Steel Wages Board. The parties to have mutual rights in calling meetings of the Board, such meetings to be held within 14 days. (2) National negotiations and awards: It is agreed that in future both sides will become parties to (*a*) national negotiations, (*b*) national awards to which they may be invited. Any claims and proposals of a national character to be forwarded to the Wages Board immediately they are formulated. (3) A meeting of Mr. Hutton (for the employers) and Mr. Bevin (for the men) to be held at a later date, to agree as to what amount, in addition to the 6s. per week granted from May 3, shall be given in settlement of the present difference. (4) Work to be resumed where possible on Monday, May 24.

The biennial congress of the National Union of General Workers was opened in Aberdeen last Monday, when Mr. J. R. Clynes, M.P., the chairman, delivered a presidential address. In this he referred to the operations of capitalist bodies and their menacing amalgamation, and said a protest against the trusts should not be left to trade unions. It was vital that the whole country should understand what was happening to trade and business. Because of capitalists there was little left now of what they used to call free trade. Trusts fixed prices of the raw material and the finished product. They controlled the purchase and sale of material and determined the amount the public must pay. They were the great destroyers of the traditions of trade and interfered with industrial service far more effectively than trade unions had ever done. Those who said Labour interfered with trade developments should look at the way in which syndicates and trade associations working in secret prevented freedom in business by artificially fixing prices and always considering profits, with little regard to production or the people's needs. Labour rejected this law of monopoly and private control of the people's needs, and in its demand for nationalisation Labour showed itself the greater patriot by seeking to acquire property for the nation in order to advance the well-being of the community. The abandonment of political effort and the resort to violence, Mr. Clynes further stated, would not merely disturb and dislocate all the commercial and productive resources of the country, but would assuredly bring the whole people very soon to the verge of starvation. Our internal welfare depended upon external food supplies. This was entirely overlooked by those who contemplated methods of physical force with unconcern. To disturb the credit and trading arrangements of an island like ours was to shut against us the doors of food markets in every part of the world. There was no country less qualified to bear the burden of continued internal disturbance than Britain.

THE NORTH BRITISH LOCOMOTIVE COMPANY, LIMITED.—The war record of the North British Locomotive Company, Limited, takes the form of a pictorial album preceded by a short historical account of the firms which go to make up the present company. Of these firms the first to place a locomotive on the rails was Messrs. Sharp, Roberts and Co., subsequently Messrs. Sharp, Stewart and Co. Their first locomotive was finished in 1833. The twenty thousandth engine was turned out in 1913. Although the firm continued building during the war, and turned out over 1,400 engines in that period, it undertook an enormous amount of actual munitions work of too diversified a nature to specify in detail. A large amount of shell-making was done in shops which were in process of erection in 1914. The output also included sea mines, double and triple 21-in. revolving torpedo tubes, B.E.2c aeroplanes, 240-mm. trench howitzers and last, but not least, Mark VIII tanks. An order for 1,040 of the latter was passing through the shops at the time of the armistice. The book contains a large number of reproductions of interesting photographs, and ends with an interesting description of the Springburn Red Cross Hospital of over 400 beds, which was installed in the administration building of the works. This forms a splendidly pleasant ending to the proud, but of course somewhat grim, record of munitions turned out on the other side of the wall so to speak, in the works themselves.

PRECISION LEVER WATCHES.

THE plain lever watch is not generally regarded as an instrument of precision, but within recent years it has been brought to a degree of accuracy higher than that of the pocket chronometer, which is more elaborate in its design and more delicate in its mechanism. This improvement has been due to a combination of high mechanical skill with scientific study of the most suitable materials. In the watch and chronometer trials at the National Physical Laboratory during 1917 and 1918, the first place was taken by a keyless, double-roller, going-barrel lever watch made by Mr. Paul Ditisheim, of La Chaux-de-Fonds, Switzerland, with the highest number of marks recorded up to that time —96·2 out of a possible 100. The full number is allotted to an absolutely perfect watch, which shows complete absence of variation of daily rate, absolute freedom from change of rate with change of position, and perfect compensation for effects of temperature. Tests made by the National Physical Laboratory during March and April of this year showed still better results, the figure reached being 96·9. This remarkably high standard of accuracy has enabled watches of this type to be used with good effect in the determination of longitude. In the autumn of 1918 a set of watches was taken from Neuchatel to Washington, U.S.A., and gave the following determinations, which are compared with the standard determinations made with wireless telegraphy:—

	Standard Determination. h. m. s.	Determination by Lever Watches. h. m. s.
Neuchatel-Bordeaux ...	0 29 55.3	0 29 55.3
Neuchatel - Washington	5 36 5.6	5 36 4.0

Thus the longitude of Bordeaux was accurately given, while in the case of Washington the reading was only 1·6 seconds out—equivalent to about 400 yards. The notable point about this test was that the watches were not specially protected against the effects of vibration and change of position. Owing to their portability and robustness they are particularly well suited for surveying and exploration. The standard equipment in such cases is a set of three watches fitted into pockets in a belt. By taking the mean of three readings a higher standard of reliability is obtained than is possible with a single watch.

In order to test the degree of accuracy obtainable with the most recent watches, Mr. Paul Ditisheim has recently used them in determining the difference in longitude between London and Paris. Aeroplane transport was adopted to shorten the transit period between the observatories at Greenwich and Paris, thus reducing the margin of possible error. Three journeys were arranged, two from London to Paris and one in the reverse direction. The results of this unique test will be awaited with interest. It may be mentioned that the high standard of accuracy reached by these watches is due to the adoption of the Guillaume balance, which is made of a special nickel-iron alloy which automatically compensates for changes in temperature. The modulus of elasticity of the spring increases with the rise in temperature.

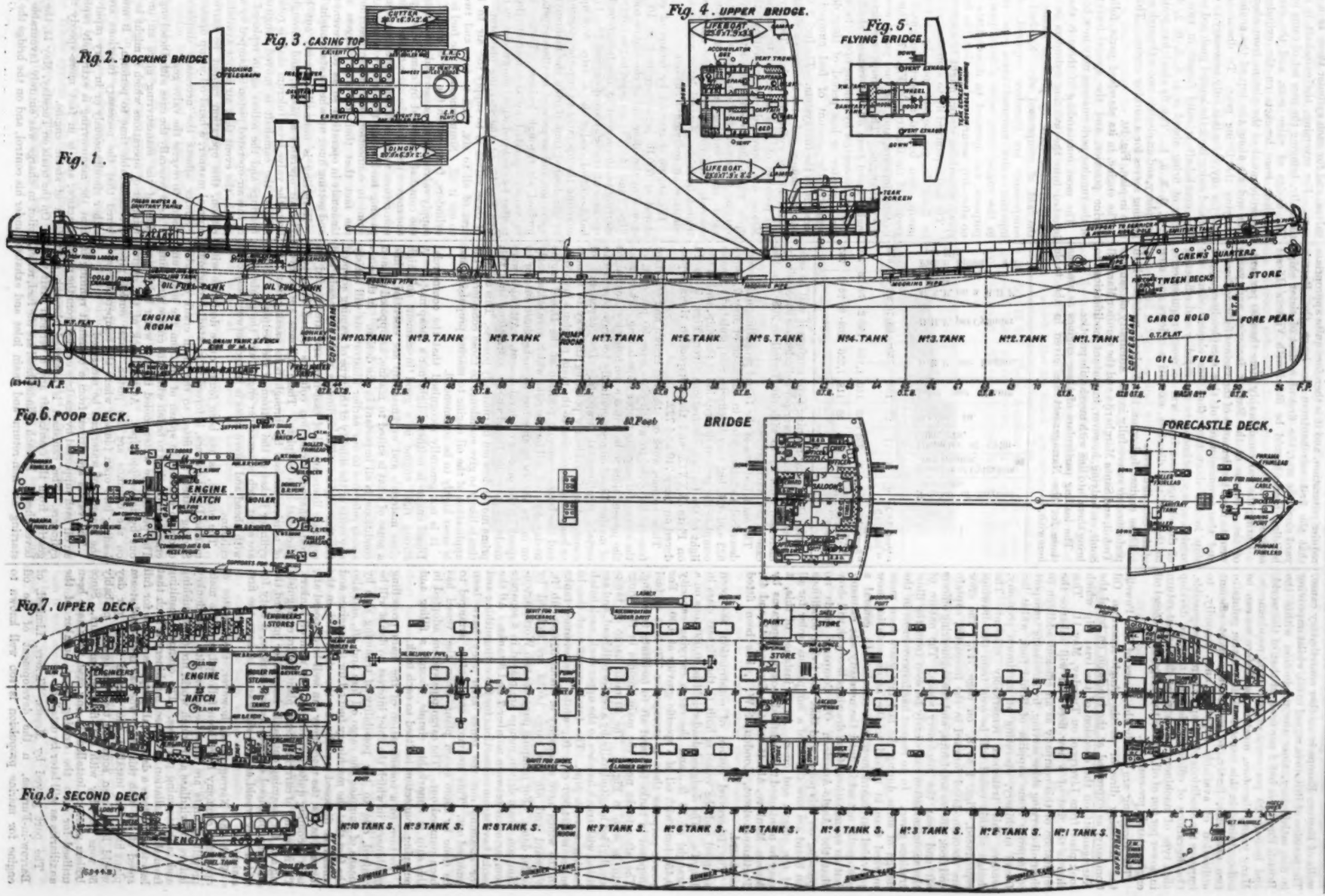
THE MOTOR SHIP "NARRAGANSETT."

ONE of the most far-reaching movements of the present day is the utilisation of oil fuel for power production. The relative prices of oil and coal in a great number of the world's ports, are such that, in many instances, a good case can be presented for the substitution of the liquid for the solid fuel. Furthermore, the relation in running charges between the cost of fuel and of labour throughout the world have been considerably altered by the conditions appertaining to-day, and principally by the high wages everywhere demanded. In respect of labour-saving, of course, the advantages of oil fuel are well known. A large number of ships are being built to burn oil fuel under boilers, or, being converted to this system, and the Diesel engine is also being extensively fitted.

The question of the sufficiency of the world's supply of oil fuel cannot but be raised; shortages have already been felt in certain quarters and give rise to the fear that consumption is out-distancing production. An urgent note of warning must be issued as to the absolute necessity of consuming the available supply to the best advantage. Looking back over the history of the great developments attributable to the utilisation of the world's coal deposits, the fear arises that just as coal has been needlessly wasted, so is there at present the danger of similar economic disregard where the newer liquid fuel is concerned. Whatever shortages of oil fuel may temporarily be felt at intervals in various quarters, these are no doubt more due to the five years of war than to any other cause. The war requirements of the Allies for aeroplanes, tanks and all types of transport, drew very heavily upon the available reserves of the lighter spirits, and consequently upon those also of heavier oils. The destruction of the oil

MOTOR SHIP "NARRAGANSETT" FOR THE ANGLO-AMERICAN OIL COMPANY.

CONSTRUCTED BY MESSRS. VICKERS, LIMITED, BARROW-IN-FURNESS.



wells of Eastern Europe is another contributory cause. The position of Britain in regard to oil, whilst improving is not satisfactory, since the production within the British Empire is but 2 per cent. of that of the world, and is only 20 per cent. of our own requirements. Many years, therefore, must elapse before we can be self-contained in this respect. This position points to two essentials, firstly, to ensure the most efficient utilisation of available supplies, and, secondly, to improve the conditions of transport as much as possible. Considerations of efficiency demand that we develop that type of machinery which gives the largest return in power per ton of oil, and in this respect the Diesel oil engine stands pre-eminent.

The foregoing are briefly the views of Mr. Powell, the managing director of the Anglo-American Oil Company, as expressed at the luncheon on board the Narragansett on the occasion of the trial trip which took place from Liverpool on Tuesday, May 11. This ship is the first of a new fleet and will enhance the reputation of this company as an efficient addition to their oil-carrying ships serving, by increasing transport to improve home supplies of liquid fuel, whilst her Diesel machinery, operating at maximum economy, renders this transport remarkably efficient. The design of this vessel will be seen from the drawings reproduced, Figs. 1 to 8, on page 717. The crew are accommodated forward in the forecastle, captain and deck officers amidships, and the engineering officers aft and near the machinery space. The nature of the accommodation can clearly be seen from the illustrations given. In no respect has improvement in the design of ships during the last few years been more marked than in regard to the accommodation now provided on board merchant vessels. In general a change did not set in until the necessity was clamant, but an examination of the drawings herewith will show that the Anglo-American Oil Company needs no pressing on this point, and that the living conditions on board are now almost of a sumptuous order for all of the officers and crew. As an instance of this, it may be mentioned that oil-fired cooking apparatus by Messrs. Manlove, Alliott and Co., Limited, 41 and 42, Parliament-street, London, S.W. 1, has been fitted on board.

The Isherwood system of construction has been adopted and the vessel is built to the highest class in Lloyd's. The designed deadweight is 10,050 tons on a draught of 26 ft., and the cargo carrying capacity 9,450 tons with oil of a specific gravity of 0.90. For power purposes there is storage for 750 tons of fuel disposed in tanks fore and aft to facilitate trimming. The after tanks near the main engines in the wings can be seen in Fig. 1. The 10 main cargo oil tanks are divided longitudinally by a centre bulkhead, and are fitted with trunk hatches to the upper deck, each hatch having a vent pipe. The total capacity of the 10 tanks is 434,000 cub. ft., whilst the summer tanks in the wings have a capacity of about 52,000 cub. ft. Forward and aft the cargo tanks are isolated by coffer dams. For pumping purposes two Worthington-Simpson steam driven pumps are placed in a separate compartment between number 7 and 8 tanks. All the tanks have steam connections for fire extinguishing and for steaming out the tanks after they have been pumped out. This steaming out is often arranged to be done by shore steam plant when the vessel has been pumped out. The cargo pipe system adopted in this ship is remarkably simple, though a filling and pumping connection is fitted to each tank.

To turn to a consideration of the main propelling machinery, in which the chief interest no doubt will be centred, due to the possibility of trimming ship by means of pumping the cargo oil fore and aft, and also the fact that the machinery fuel oil for the engines and boilers is disposed equally at the stern and in the forward tanks, the machinery can well be disposed aft, as is becoming quite general practice with oil tankers. The necessity of carrying steam plant for fire extinguishing and for steaming out tanks has rather impeded the adoption of Diesel engines for oil tankers, a duty for which they would at first sight seem to have the first claim.

With the Narragansett, however, the dictates of operating economy have been followed, and the main propelling units are Diesel engines with two donkey boilers for windlass and winch work, fire-extinguishing and tank-steaming purposes. The economy resulting from the installation of Diesel machinery is such that less than 11 tons a day for all purposes serves for full speed at sea with this ship, whereas if oil-fired steam plant had been installed the service figure per day would have been some 30 tons as against probably 50 tons per day with coal-fired steam plant. Since boilers must be installed, in any case, they have been utilised for also the driving of a number of the auxiliaries as will later be detailed.

The part played by Messrs. Vickers, Limited, of Barrow-in-Furness, n the development of the oil engine for marine propulsion is too well known to require reiteration, and it is therefore quite appropriate that the first merchantman to leave the Barrow yard since the war, the first of a fleet of sister ships building there, should be fitted with Vickers' Diesel engines.

During the war considerably more than 90 per cent. of the products of the Barrow factories and yards went to meet the demands of the various fighting forces, and the commissioning of this completely-equipped ship in the short time that has elapsed since the armistice, is a testimony to the rapidity and efficiency of the change over from war to peace requirements, to the credit of directors, executive officers and men of the establishment.

These engines follow on the Vickers' motors which performed so successfully in the Admiralty oil tankers Trefoil, and Santa Margherita and the monitor Marshall Soult, embodying, however, important modifications to bring them into line with mercantile practice.

The leading particulars of these engines as well as those for the Narragansett are given in the table herewith :—

—	Number of Engines per Ship.	Number of Cylinders per Engine.	Diameter of Cylinder. In.	Stroke. In.	Revs. per Minute.	B.H.P. per Engine.	B.H.P. per Cylinder.	M.E.P. on a B.H.P. Basis.	Piston Speed. Ft. per Min.
"Trefoil" & "Marshall Soult"	2	8	17	27	150	750	93·75	80·9	675
"Santa Margherita"	2	8	20½	33	140	1,250	156·2	79·25	770
"Narragansett"	2	6	24½	30	118	1,250	208·3	76·0	767

With these slow-running type engines it will be seen that the brake horse power per cylinder has successively increased from 93·75 with the Trefoil to 208·3 in the case of the Narragansett.

The main features of the Diesel propelling units were described and illustrated in our issue of May 7, pages 623 and 624, but may briefly be recapitulated to make complete the present description of the ship, and in the light of the further illustrations given, Figs. 9 to 14 on Plate XXXIX and the perspective views reproduced on pages 719 and 722.

These engines work on the well-known and standard four-stroke cycle, to which class over 90 per cent. of the successful seagoing motor ships belong. There is at the present time to be noted a tendency for the designs of marine Diesel engines gradually to draw together in certain fundamental respects. The experience of constructors is evidently pointing the way to a more or less common solution to the main problems involved, and the better economic position of the Diesel engine to-day does not call for the risks which were taken early on in its history in an effort to make short cuts or to speed up the process of development. Attempts were made to give the Diesel engine attractions that this prime mover does not intrinsically possess. This unification is likely to give confidence to those considering the application of the oil engine to marine propulsion and is most highly to be commended.

It is not generally recognised that the commercial Diesel engine is neither a light nor a cheap motor. A strong rigid engine is a good investment and high class materials and workmanship are essential, while a sense of what is suited to marine, as opposed to land conditions, is all important in the design. In these respects reference to our earlier illustrations will satisfy any critic of the solidity of the type of framing adopted for this engine. The cylinders with the heads and separate liners are all of cast-iron and are carried on trestle-shaped box-section columns bolted to a two-piece cast-iron bedplate. These columns are relieved of tension stresses by through bolts passing from the cylinder jacket to the bottom of the bedplate. There are eight such columns per engine and the guide plate with ahead and astern faces is bolted between adjacent columns.

The engine, as has been found quite desirable with marine Diesel engines, is forced lubricated throughout. Sliding panels are fitted to the main crank chamber doors to enable the splash of oil from the main and crank-pin bearings to be felt whilst the engine is running. The pistons are water cooled by salt water led in and out by telescopic pipes. At the back of the engine on the columns are the piston water outlet pipes leading into open funnels where the temperature and the amount of water can be measured.

The valves are driven from a camshaft running in an oil bath supported by brackets carried from the main cylinders. The camshaft is operated through spur gearing from the crankshaft and a vertical shaft with bevel wheels. In each cylinder head are the fuel, relief, starting air non-return and main inlet and exhaust valves, and for each cylinder there is a double set of cams. For reversing, the camshaft is shifted longitudinally, bringing the new set of cams into operation. The design of valve gear, and the carrying of the camshaft from brackets on the cylinders, facilitates the withdrawal of the pistons from above. Running fore and aft along the top of the engines is a beam carrying the lifting gear. To disconnect the valve gear for any valve it is only necessary to drive out one pin and swing back the angled push rod seen in Fig. 16. The crankshaft is solid forged in two pieces. The order of firing ahead is 1, 5, 3, 6, 2, 4, and astern 4, 2, 6, 3, 5, 1. The flywheel has teeth cut on the periphery, and an electric motor through worm and spur gearing serves for a turning engine. This gear can be seen in plan, Fig. 10.

The engine, in its standard parts, follows the best marine practice, and the special features and notes of the running performances may now be given.

The most outstanding of these is that the fuel is injected into the working cylinders in a sufficiently finely-divided state by pressure alone, and without the aid of compressed air. No fuel injection air compressors are therefore required. A spare fuel-injection valve mounted upon one of the pillars in the engine-room, with a hand pump for testing purposes, was operated to demonstrate the fact that no after-drip occurs, and so that the fineness of the spray, resembling steam, might be appreciated.

The fuel is pumped up to a pressure of from 4,000 lb. to 5,000 lb. per square inch by a four-throw fuel pump, seen behind a sheet-iron guard in the foreground of the illustration, Fig. 17. This view is taken looking forward, and the fuel pump seen is that for the port engine. These pumps are driven at about engine speed from off the vertical shaft gearing. A system of control by holding open the suction valves for a greater or less period of their delivery stroke regulates the amount of fuel pumped, and so the pressure in the fuel system. The fuel is then delivered into a common rail and thence to the fuel injection valves in the cylinder heads. This system reduces the problem of fuel injection to its simplest terms. Means are provided by operating the eccentrics upon which the fuel-injection levers are mounted for varying the amount of opening of these cylinder head valves and of cutting them out of action altogether, if desired. The timing of all the spray valves is controlled from one control lever, and each valve has in addition an individual cut-out.

The engine is started by means of compressed air stored at 600 lb. per square inch in 10 air reservoirs stowed at the after end of the engine-room, as seen in Figs. 9 and 14. The air is led to the control valve at the starting platform seen in the foreground low down in the case of the starboard engine, Fig. 17. Above this hand-control valve is a trip foot-operated valve enabling the operator to trip the starting air on or off at the desired time during the manœuvring period of operation and so prevent needless expenditure of compressed air through leakage. Thence the air is led to valves operated by the manœuvring shaft controlled by the hand wheel shown clearly in the illustration Fig. 17, of the starting platform. The function of these valves is to supply the air to the cylinders, first of all to six, then to four and two, and finally to cut it off. Simultaneously the fuel is passed to the cylinders, from which the air is cut off. From these supply valves the air passes to distributing valves below the camshaft operated by cams which pass the air at the correct period of the cycle to the cylinders, where a non-return valve is fitted to prevent combustion gases passing back along the supply pipes. An interesting point in connection with these distributing valves is the fact that their driving plungers are kept continuously in operation so as to prevent them sticking and getting hung up when a start might be required.

Reversing is normally carried out by air power. The air operates a piston, and through gearing and links the valve lever fulcrum shaft is rotated lifting the rollers, the camshaft is moved longitudinally in its bearings and the rollers again replaced. The motion of this air-operated piston is damped by an oil cylinder, and in the event that air is not available or for other reason, this operation cannot be carried out in the normal manner, a hand oil pump operating on the oil cylinder affects the necessary displacement of the piston to reverse the valve gear.

As is generally the case with Diesel engines a description of the manœuvring gives an impression of a number of operations which it might be assumed take a considerable time to perform. It must be remembered that the necessary functions are carried out either simultaneously or in very rapid succession, so that the manœuvring is extremely rapidly effected in practice, and is in fact more speedy than with any form of steam engine.

On the trials on Tuesday, May 11, the opinion of the pilot in charge was entirely favourable to the engine under his control, and on the bridge the McNab indica-

tors proved that the response in the engine-room to the orders from the bridge was immediate and sure. A considerable amount of manœuvring was carried out when weighing anchor and swinging, in limited space, in a busy stream with a slight mist on the water. When going into dock after the trials 55 reversals and starts were required from each main engine in 1¼ hours. On several occasions reversal from ahead to astern took only 8 seconds.

Slow speed on the engines corresponds to slightly more than 40 r.p.m. and full speed to 120 r.p.m.

Driven by means of levers and drag links from the crosshead of the forward main engine is a group of pumps disposed as follows: a bilge and sanitary, and a forced lubricating oil at either side, centrally a pump for circulating the salt water for the jackets and above it a small pump for higher pressure salt water for the piston, exhaust valves and their cages, and the auxiliary service for the cylinder heads.

From the same mechanism the compressor for the McNab indicators fitted on the bridge is driven.

The lubricating oil pressure is 20 lb. per square inch, the circulating cooling water 10 lb., and the high-pressure water system for the pistons, &c., is 20 lb. to 22 lb. per square inch.

Fig. 16 reproduces a photograph taken on the top platform looking forward, and shows the services in connection with the port engine. The flexible pipes lead the water in and out of the exhaust valves. The service fitted for cooling the exhaust valve cages is also shown. The auxiliary service for the cylinder heads sweeps across the face of the head exposed to combustion and prevents the lodgement of deposits of mud from the circulating water. Open funnels are provided where the discharge is visible. Individual slotted pipes to each cylinder serve for the induction air. The exhaust pipes are well lagged, and the main along the back of the engine is protected as well with planished steel.

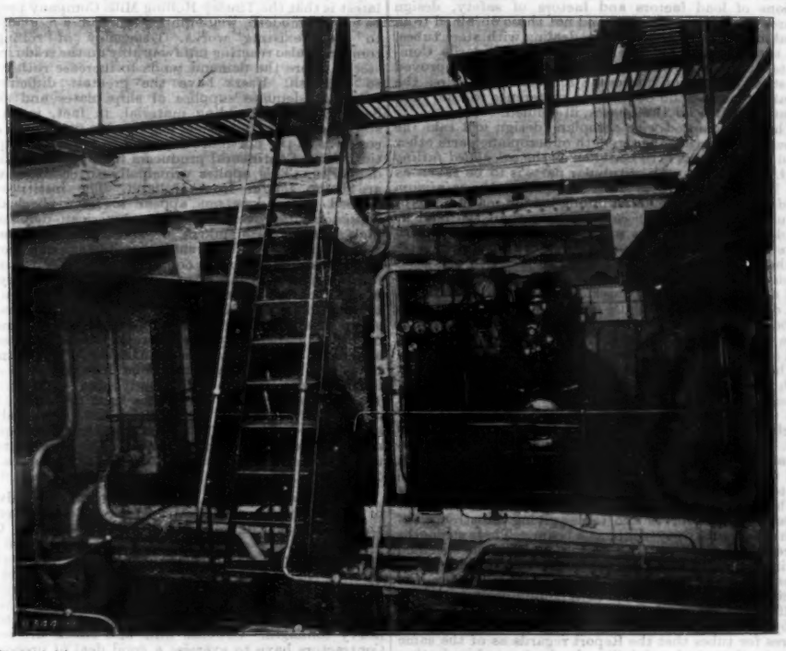


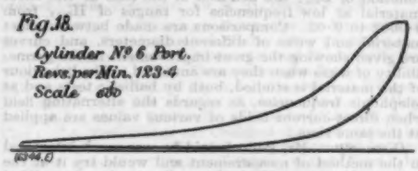
FIG. 15. TOP FLAT, SHOWING AUXILIARIES.

As evidence of the care bestowed upon the design mention might be made of the cylinder lubrication. Two forced feed-boxes of four pumps each, feed to each liner which is provided with eight feeds, so that in the event of any one or more of the leads becoming stopped up an ample supply of lubricant is assured.

To turn to the machinery installation apart from the main engine, steam is generated in two boilers, the larger a cylindrical boiler with three furnaces can be seen in the illustrations. It is carried on beams over the forward end of the main engines (Fig. 9), and is also shown in the sections, Figs. 11 and 12. The smaller serves for the supply of steam for all purposes when the ship is under way, and is placed in a compartment forward of the main engines. This boiler is of the Cochrane vertical type. Both are fitted with the White system of oil-fuel burning by Messrs. Brigham and Cowan, including pumps, heaters, filters, &c. The gases from the boilers are led up separate funnels, included in the same outer casing that carries the two exhaust pipes from the main engines, as is well illustrated in the sectional elevation, Fig. 11, about frame 38. In the engine-room on the floor level are placed on the port side a Contraflo condenser for the auxiliary exhaust, a Brotherhood compressor of a capacity of 150 cub. ft. per minute compressing to 600 lb. per square inch for the starting air reservoirs, a feed water cleanser and the feed pumps. Similarly on the starboard side are the ballast pump and the fuel oil transfer pump. In the wings are the fire and bilge pump, and the stand-by water circulating pump, whilst between the main Michell thrust blocks is a stand-by lubricating oil pump. The stern tube is fitted with glands and is kept supplied with lubricating oil from a tank in the engine-room. The propellers are of solid cast bronze, outward turning, and are three-bladed. On a flat at the after end of the engine-room is a refrigerating engine, a Vickers-Petter 25-kw. oil engine and dynamo, and a Matthew Paul steam-driven dynamo. These two machines are seen in the view of this flat, Fig. 15. The windlass and cargo winches, three of which latter are fitted, are steam-driven, two of the winches having cylinders 7 in. by 9 in. and one 8 in. by 12 in. There remains the steering gear. Instead of being steam driven, this is of the electro-hydraulic type. An electric motor driving a Williams-Janney variable speed oil pump supplies the power to rams operating on the tiller of the rudder. This gear is very economical and silent in operation, and experience has shown that the sensitive control possible enables a ship to be kept on its course with very much less movement of the rudder than with the usual steam gear. On trial the amount of current taken when the rudder was in normal action to maintain a straight course was 5 amperes.

The trials were attended by Messrs. Powell and Hamilton, directors of the Anglo-American Oil Company, Mr. Bramwell, their Liverpool manager, and Mr. Maclean, the manager of their Shipping Department. The weather was fair, sea calm, with a light wind most of the time. An 8-mile course was traversed both ways at full power to ascertain the speed, the trial being continued for 6 hours. The guarantee speed of the ship, 10·5 knots, was well exceeded, the mean speed on this trial being 11·24 knots, the ship being ballasted down to her marks. The brake horse-power corresponding to this speed is a total of 2,650 brake horse-power or 1,325 brake horse-power per engine at an average of 123·5 r.p.m. During 3 hours of the 6 hours' trial the fuel consumption of the main engines was accurately measured and gave a figure which for 24 hours represents a consumption of 10·6 tons, or less than 0·42 lb. per brake horse-power per hour for these Diesel engines. The fuel oil used was Anglo-American Diesel oil of a specific gravity of 0·894 and a full calorific value. During the whole of the trial the exhaust was excellent, only a slight haze, attributable to the main engines, being visible above the main funnel. Any smoke which occasionally showed was due to the donkey boiler in action for the driving of auxiliaries. When starting up the engines a puff of lubricating oil smoke could be observed, but on trial trips the supply of lubricant is more ample than will be necessary when on service.

During the trial exhaust gas analyses were taken, and showed that combustion was complete. A typical



indicator card taken from cylinder No. 6 port while on speed trial, is given in Fig. 18. From this it can be seen that the combustion is taking place well towards the beginning of the power stroke as is desirable. The compression pressure reads 420 lb. to 440 lb. per square inch, and the maximum pressure less than 500 lb. per square inch. This is a very satisfactory card. Throughout the trial the engine ran steadily and entirely free from any sign of vibration, while the starting was particularly smooth. In every way the trial was a complete success, and all concerned, including the designers and constructors are to be congratulated.

PHYSICAL SOCIETY OF LONDON.

AT the meeting of the Physical Society of London, held on Friday, May 14, 1920, at the Imperial College of Science, Professor Sir W. H. Bragg, F.R.S., President, in the chair, a Demonstration of Experiments on the Thermionic Properties of Hot Filaments was given by Dr. F. Lloyd Hopwood.

The experiments shown were some of those described by Dr. Hopwood in the *Philosophical Magazine*, March, 1915, page 362, in which the glowing filament of a carbon lamp, and glowing filaments of nichrome and platinum in air are made to move under the influence of positively and negatively charged rods brought into or withdrawn from their vicinity; the character of the effects observed being such as to give a qualitative indication of the thermionic emission from the filaments. In addition he showed a type of tilted electroscope in which the gold leaf was replaced by a narrow loop of Wollaston wire. When a current is passed through the wire so as to make it glow, it forms an electroscope of different sensitivity for +ve and −ve charges.

Discussion.—Mr. W. R. Cooper asked if the experiments had been tried with lamps lacquered with coloured lacquers. He had seen one covered with a red lacquer, the filament of which would move about following movements of the finger outside. Dr. D. Owen asked what was the explanation of the asymmetry of the electroscope. Did it depend on the direction of the current in the filament, or did it work as well with alternating current? Dr. Hopwood said it was possible with lacquered lamps that one got an adventitious charge on the globe which reacted on the filament. He mentioned that during the war he knew of a number of lamps which in order to obscure them were dipped in "tantalum paint." This was so easily electrified when touched by dry hands that about 50 per cent. of the filaments broke. In reply to Dr. Owen, he added that the electroscope worked equally well with alternating current.

A paper on "*A Modified Theory of the Crookes Radiometer*" was read by Mr. G. D. West. The paper gives a short account of a theory of the Crookes Radiometer worked out by Sutherland in 1896, but unfortunately much neglected. The theory as it stands will not explain many radiometric phenomena, but it is shown that when modifications, depending on the modern knowledge of thermal surface conditions, are made, such explanations become possible. Radiometer action, especially at the higher gas pressures, would appear to depend essentially on the formation of gas currents near the radiometer vane. These currents are distinct from convection currents, but are closely associated with the phenomena of thermal transpiration.

Discussion.—Mr. F. J. W. Whipple pointed out that as the isothermals were drawn in Fig. 4 they indicated that the colder side of the vane was actually colder than the walls of the bulb, whereas actually it was hotter. He indicated alterations in the shape of the isothermals which would correct this. In connection with the general presentation of the problem he would have liked it better if it had been based more on kinetic theory and less on hydrodynamical flow. It was necessary to introduce kinetic theory to explain the difference of pressure between the hot and cold ends of a tube. When the mean free path was large, a particle entering one end of the tube would strike the sides tangentially and pass through the tube. When equilibrium was reached the number of particles entering at each end must be equal, so that $\rho v = \rho' v'$. But the condition for equality of pressure was $\rho v^2 = \rho' v'^2$.

Mr. West, in reply, said he was not quite clear at the moment on the point raised about Fig. 4. He would look into it and communicate a reply. In an earlier paper he had pointed out what Mr. Whipple had just mentioned, that at low pressures it was the conservation of matter

that determined equilibrium, while at high pressures it was the equality of pressures.

A paper "*On the Magnetic Properties of Silicon Iron (Stalloy) in Alternating Magnetic Fields of Low Value.*" by Mr. Albert Campbell, was read by Mr. D. W. Dye. Measurements are described of the hysteresis losses in silicon iron sheet and wires in very low alternating magnetic fields at low and telephonic frequencies using an alternating current method described in a former paper. The equations giving the hysteresis losses as a function of $B_{max.}$ are deduced in the case of the sheet material at low frequencies for ranges of $H_{max.}$ from 0·0002 to 0·02. Comparisons are made between sheet material and wires of different diameters, and curves are given showing the great improvement in the permeability of wires when they are annealed. The behaviour of the material is studied, both by ballistic tests and at telephonic frequencies, as regards the alternating field when direct-current fields of various values are applied at the same time.

Discussion.—Mr. Pollock said he was much interested in the method of measurement and would try it at the first opportunity. He had usually employed modified bridge methods and had got down to magnetising fields of 0·02, but not so far down as the author. He was interested in the formula for eddy current losses. He had frequently found in measurements with fine wire cores that the eddy current loss takes jumps due to the E.M.F.s set up being sufficient to make the currents pass from one strand to another, and he thought it was impossible to calculate the eddy current losses by any formula. It was important in practice when measuring the losses in stranded cores to take account of the value of the magnetic field to which the core would be subject in use, for with some fields the eddy currents would pass from strand to strand, while with others they would not. He was interested in the conclusion that hysteresis loss was proportional to the square of the flux density. He had had the impression that the loss became very small at very low fields. With regard to the figure showing the permeabilities for unannealed and annealed stalloy, it was most important in telephone work that the cores of the loading coils should be of constant permeability over the range of field to which they were subject in use. Unfortunately such cores were liable to damage by excessive magnetisation due to accidental currents flowing through the coils, as their permeability did not return to its initial value. Many of the old coils had lost about 15 per cent. of their inductance from such causes. This could only be recovered by re-annealing and unfortunately annealed stalloy had not constant permeability. On this account the Americans were beginning to use granular cores.

Mr. Ritter asked if the windings were absolutely dry, as he had found that a trace of moisture in the dielectric caused quite appreciable losses. He emphasised the importance of constant permeability in the iron used for loading coils. When a cable was loaded the impedance depended on the square root of the ratio of the inductance to the capacity per unit length. If the impedance altered with the current, difficulties were introduced, especially since the use of amplifiers became general.

Mr. Dye said the greatest care was always taken in winding the coils to prevent the possibility of moisture being present. As regards the telephone coils, was the iron in its virgin state to start with? If the cores were magnetised strongly to begin with and then demagnetised, the properties in that state being used as the basis of design, it would always be possible to regain the initial condition without re-annealing.

A paper "*On Tracing Rays Through an Optical System,*" was read by Mr. T. Smith. Equations for tracing rays in an axial plane through an optical system have the normal refraction terms separated from those representing aberrations. By expressing the latter as a fraction with the first order aberration as the numerator and a correcting factor, which may take various forms, as the denominator, rays may be traced exactly through the system using a short table of cosines in terms of sines in place of the extensive tables, giving sines in terms of angles generally employed. A considerable saving of time is effected in the calculations and the estimation, without calculation, of the aberrations of other rays is facilitated.

LONDON TRAFFIC AND GARDEN CITIES.

TO THE EDITOR OF ENGINEERING.

SIR,—I am much interested in the article on "London Traffic" in your issue of the 14th inst. Its closing words, which I venture to quote, are very forcible: "At present we have people building at various places—others are discussing transport. Before the question will be solved all these must come together and work together instead of putting up requirements for some one to fulfil without regard to their feasibility or advisability."

Now certainly this charge cannot be levelled against those who advocate garden cities. For garden city proposals, already illustrated at Letchworth, Herts., where there are now 40 factories in what was a few years ago a decaying agricultural district—and about to be further developed at Welwyn, within 21 miles of London, do deal simultaneously with the problems you refer to, and indeed with others also. And this in the most economical fashion that has ever been devised. For by decentralising industries, and by providing London workers, who now spend long hours and much money and energy in travelling in discomfort to themselves and their neighbours, with comfortable cottages with good gardens, within a short distance of their work and their play, some diminution of the strain on London's traffic system will be effected. Further, by thus bringing many consumers within easy reach of supplies of milk, vegetables, fruit, &c. (in addition to the produce of their own gardens), food values now lost by delays in transport will be saved, and some reduction also made in the strain on the transport system of the country generally.

The problem is so vast that the effect of two or three such towns will be scarcely noticeable. But multiply such places as Letchworth and Welwyn by the dozen and the good effects will be very clearly seen, while the health of the people who go and the health of those who remain will be greatly improved and much cause for discontent on the part of the workers will be removed.

Yours faithfully,

EBENEZER HOWARD.

3, Gray's Inn-place, Gray's Inn, London, W.C.,
May 19, 1920.

[The words quoted by our correspondent were not intended to apply to advocates of carefully-planned garden cities or satellite towns. Recent articles in these columns (such as those on pages 121 and 517 *ante*) show that we consider these enterprises capable of affording relief to some vexed London problems.—ED. E.]

"LOAD FACTORS FOR AEROPLANES AND SEAPLANES."

TO THE EDITOR OF ENGINEERING.

SIR,—The Report of the Sub-Committee on Load Factors for aeroplanes and seaplanes, published in your issue of April 16, has been the subject of considerable criticism, but one clause, which appears to me to be irrational, seems previously to have escaped notice. As it is somewhat involved it is perhaps best to reproduce this clause, which reads: "In all calculations and in specifications of load factors and factors of safety, design figures should be employed and not those obtained from breaking tests. Further, when dealing with steel tubes, the specifications of the Engineering Standards Committee, based on the figures for yield-points are approved for stress calculation purposes; for streamline wires the breaking load should be taken in preference to the yield point, which is in these cases, ill-defined."

Those acquainted with aeroplane design will take the above to mean that the strength of aeroplane parts other than tubular parts is to be taken as the *calculated failing* load, but the strength of tubular parts is to be taken as the load that produces a stress equal to the *minimum yield* stress. The calculated failing load of many forms of tubular parts is 50 per cent. greater than the load at yield so that such parts are required by the Report to have a load factor 50 per cent. greater than other parts of the structure. Such inequality in strength decreases efficiency without increasing safety and hence enforces bad design. In certain cases, such as landing axles, it will decrease safety, because a tubular axle after it starts to bend will absorb a great amount of shock, and thus save the undercarriage or other vital parts from failing, and so converting a bad landing into a crash.

The experience gained during the war showed that with the ordinary undercarriage the most satisfactory axles were those which on test had a load factor of 3·5 to 4. The Report now requires the same type of machine to have axles about three times stronger than this. It is certain that the Report will be reconsidered at an early date, and I wish, therefore, to point out a further, and to my mind, a more important aspect of the above-quoted clause.

The standard tube specifications referred to in the Report contain curves and tables giving the strength of each size of tube as a strut or as a beam. These strengths represent the load that would just develop the specified minimum yield stress in the most badly bent, most eccentric and thinnest tube acceptable under the specifications—in a tube, in fact, combining together in itself all the defects that are usually left to be taken care of by the factor of safety. These are evidently the figures for tubes that the Report regards as of the same value as the calculated *failing*, load of wood and other parts. The standard specifications for high-tensile steel tubes for axles requires every tube to be proof loaded to the figure given in the specification as its strength at yield, and only tubes are passed for use that are not sensibly bent in this test. The failing strength of axle tubes is more than 30 per cent. above this figure. In a specification for high-tensile steel tubes for general purposes that is about to be issued, each tube is similarly proof-loaded to the specified yield stress. All this thoroughness of testing has been undertaken by the manufacturers to enable a safe strength figure to be given for each tube on which the designer can absolutely rely, so that he need employ the minimum factor of ignorance. Instead of utilising this thoroughness of testing the Report penalises it to an extent that it will prevent tubes being used for many purposes for which they are in reality better suited than wooden members.

I think the "Sub-Committee" will agree that a larger factor of ignorance must be used with wood than with steel to obtain equal safety, and hence if the load factors specified by the sub-committee include a sufficient "factor of ignorance" for wood, smaller load factors will give equal safety with steel and still smaller "load factors" will give equal safety with steel members that have each been proof loaded to loads corresponding to these "load factors." In my opinion a steel member that has been proof-loaded without injury to load of 5 W is more certainly good for a load of 4½ W than a wooden member having a calculated *failing* load of 8 W.

I consider that the report seriously and unfairly handicaps the designer who is endeavouring to replace wood with metal in aeroplane construction, and I trust the report will be revised at an early date to permit the use of lower load factors commensurate with the increased safety resulting from the use of more reliable materials and more conclusive methods of testing.

Yours faithfully,

H. N. WYLIE, B.Sc.

14, Church-road, Richmond, Surrey, May 12, 1920.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Cost of Labour Unrest.—The effect of repeated stoppages in iron and steel production, due to labour unrest, is strikingly illustrated in the case of the Parkgate Iron and Steel Works, Sheffield. These works were stopped for 13 weeks, or a full quarter of the past year. Loss in output aggregated 40,000 tons, while loss in wages amounted to 140,000*l.* This is only one of very many instances, but serves to emphasise the seriousness of the position.

Iron and Steel.—So busy have been the engineering trades generally during the past six months, that in most cases advantage was taken of the advent of Whitsuntide to close down works for four to five days. During the interval a large amount of necessary repair work has been undertaken, particularly in rolling mills, where the tremendous pressure on output has brought defects in plant into prominence. A resumption of activity finds the bulk of the engineering sections with extensive order books and fair prospects. The impression sought to be created in certain quarters that a marked slump has already set in in engineering purchases, is not borne out by a close examination of the position. Continental trade is distinctly easier, but otherwise there is a strong demand on home and Colonial account, and the number of firms booked up from six to twelve months ahead represent the rule rather than the exception. Deficiency of rolling-mill output is a problem that will have to be faced seriously if progress is to be made unhindered. Developments are in prospect in this connection. The latest is that the Tinsley Rolling Mills Company proposes to erect a modern, well-equipped mill on a site adjacent to their existing works. Deficiency of rolling-mill tonnage is also reacting unfavourably on the trade in mild steels, where the demand tends to increase rather than to diminish. Users have the greatest difficulty in securing adequate supplies of ship plates and sheets. Scarcity of shipbuilding material, in fact, is an outstanding feature, and local engineering firms with allied concerns in the north are reported to be inviting quotations from Continental producers to supplement British deliveries. This applies principally to castings, which are being sought from Holland. The institution of revised prices does not appear to have checked the consistent improvement in the American demand for high-speed steel. Makers of special steels generally report a robust trade, though the shortage of vanadium is causing anxiety and is compelling them to investigate for substitutes. Makers of agricultural machinery and of automobile parts are experiencing a busy season. In the lighter trades the demand for garden shears and sheep shears is well in excess of output, though makers of other garden implements report that business is adversely affected by the shrinkage in the allotments movement. The new quotations for raw and semi-finished materials represent advances ranging from 10*s.* to 40*s.* per ton. Hematites have risen 10*s.*, forge and foundry iron 12*s.* 6*d.* to 15*s.*, billets 30*s.*, and bars and hoop iron 30*s.* to 40*s.* Derbyshire foundry is quoted at 13*l.* per ton for delivery in Sheffield. The current price for Bessemer acid billets is 28*l.* 15*s.*, for Siemens acid 29*l.* 15*s.*, hard basic 26*l.*, and soft basic 25*l.* 10*s.*

South Yorkshire Coal Trade.—Following the advance of 4*s.* 2*d.* per ton on industrial fuel, coke has risen 8*s.*, and even at that figure is very difficult to obtain. Quite a number of furnaces and foundries are carrying on from day to day with the prospect of intermittent stoppages. The deficiency of transport facilities increases the difficulty of manufacturers. The strength of the market for best steam hards is fully maintained owing to the pressure on supplies. Railway companies are taking heavy tonnages. Cobbles, nuts and slacks are scarce. Contractors have to exercise a good deal of pressure to obtain contract deliveries. The demand for house coal is distinctly easier, but merchants have large arrears to make up, and supplies are coming forward badly. Nominal quotations: Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty slacks, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Holidays have interfered greatly with business this week. Cleveland pig-iron continues exceedingly scarce. Supply falls short of meeting home needs, so that it is not at all surprising to find makers adhering to their decision not to sell for export even to the allies. While there are still good inquiries on Continental account, some regular customers abroad complain of the very high rates now ruling, which are about four times greater than pre-war quotations. For home consumption, No. 1 Cleveland pig-iron is 230*s.* and No. 3, as well as the inferior qualities, is 217*s.* 6*d.*

Hematite Iron.—Shortage of East Coast hematite, while hardly so acute as is that of Cleveland pig-iron, is pronounced, and buyers experience greatest difficulty in placing orders on either home or foreign account. Any iron coming on the market is promptly snapped up, though some foreign customers are reported to be somewhat less inclined to do much buying at current rates. Producers, generally, are well placed, and are not at all pressing business. To home customers, No. 1 is

262*s.* 6*d.* and mixed Nos. are 260*s.*; and for shipment to France, Belgium and Italy, No. 1 is 267*s.* 6*d.* and Nos. 1, 2 and 3 are 265*s.*

Foreign Ore.—The foreign ore trade presents no new feature of moment. Consumers are carrying considerable stocks, and large quantities are coming forward in fulfilment of running contracts, so that, for the time being, little disposition to buy is noticeable. Users, in fact, confidently anticipate the market will become more in their favour in the near future. Nominally rubio, of 50 per cent. quality, is 49*s.* on the 17*s.* parity freight, Bilbao-Middlesbrough, which is equal to 59*s.* c.i.f. Tees for best rubio as steamers are being chartered from Bilbao at 27*s.*

Coke.—Coke keeps steady and firm. Heavy local demand is now met by ample supply. For home use medium blast-furnace kind is 62*s.* 9*d.*, low phosphorus sort 65*s.* 3*d.*, and foundry description 70*s.* 3*d.* Gas coke, for export, is quoted 150*s.*

Manufactured Iron and Steel.—In finished iron and steel the dominating factor is still inadequate means of transport. Most firms took their customary two days Whitsuntide holiday, but owing to the great congestion, due to lack of means of distribution, operations at the huge Britannia Works of Messrs. Dorman, Long and Co., have been suspended for a longer period, two steel mills there have closed for a fortnight, and other two for a week. The following are among the principal recognised market quotations, at which, however, it is difficult to make purchases:—Common iron bars, 28*l.* 10*s.*; marked bars, 30*l.* 10*s.*; rivets, 36*l.*; steel ship, bridge and tank plates, 23*l.* 10*s.*; steel angles, 23*l.*; steel joists, 23*l.*; soft steel billets, 25*l.* 10*s.*; hard steel billets, 26*l.* 10*s.*; heavy sections of steel rails, 23*l.*; and fish plates, 28*l.*

Dockers' Strike Ended.—The dockers and other riverside men in this district have returned to work, and referred the points in dispute to the negotiating committee for adjustment.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Markets.—Details of the Controller's proposals in connection with the decentralisation of control in the coal industry are to be presented to a meeting of the South Wales Coalowners' Association, and also to coal exporters, on Friday. Meanwhile business on the coal markets has been practically suspended as, in view of the three days' holiday of the miners and the consequent loss in production, the Coal Mines Department have refused to release practically any coal for export, almost the whole of the immediate output being required for home consumers and the bunkering of vessels. Shipments of coal foreign from South Wales last week amounted to 288,858 tons, or 11,790 tons less than in the previous week. Of the total, 189,487 tons, or 65 per cent. went to France, 15,005 tons to Italy, 10,901 tons to South America, 4,943 tons to Spain, 11,687 tons to Portugal, 37,476 tons to British coaling depots and 19,359 tons to other countries. As the workers on the docks were idle for the first couple of days this week, and as the miners are not expected to return to work in full force until next week, business is likely to remain at a virtual standstill. The docks are still congested with tonnage, though there are not so many vessels waiting in the roads as was the case a few weeks ago, and shippers experience much difficulty in making up even small cargoes and arranging for their bunker requirements. Prices in the circumstances are more or less nominal on the basis of 115*s.* for large, 110*s.* throughs, and 92*s.* 6*d.* to 97*s.* 6*d.* for smalls. A couple of cargoes of foundry coke has been released for export for the first time for the past six weeks. The export embargo remains, but these cargoes were released so as to enable makers to keep their ovens going over the holidays.

Important Coal and Fuel Deals.—A couple of important deals have been reported during the past week. The Ebbw Vale Steel, Iron and Coal Company, in conjunction with T. Beynon and Co., Limited, Cardiff, have acquired a controlling interest in Lancaster's Steam Coal Collieries, Limited, and now control an output of about 6,000,000 tons per annum. Messrs. D. R. Llewellyn, H. S. Berry and H. H. Merrett have acquired the whole of the share capital of 400,000*l.* of the Crown Preserved Coal Company, and now control about 80 per cent. of the output of coal briquettes of the country. The deal involves a sum approaching 2,000,000*l.* Messrs. Llewellyn, Berry, Merrett, T. J. Callaghan and P. Miles have also acquired the share capital of the Blaenclydach Colliery Company, which has an output of about 100,000 tons per annum.

Iron and Steel Trades.—It was reported on the Swansea tin-plate market yesterday that India, hitherto a large importer of Welsh tin plates, is setting up works at Bengal with a yearly capacity of about 30,000 tons, or nearly half of the total exports of Welsh tin plates in 1914. Makers are, however, not much disturbed by the news, as they are of opinion that the quality of Welsh plates will stand competition, though the possibilities of China, Japan and Australia following India's lead are not lost sight of. Meanwhile, in view of the fall in tin prices, quotations for tin plates are easier round 71*s.* for standard boxes, with business quiet. There is also less inquiry for galvanised sheets, and for 24-gauge corrugateds makers are disposed to accept about 42*l.*, against 56*l.* a week ago.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—A meeting was held on May 18 at the Birmingham Chamber of Commerce with a view to restarting the Birmingham Graduates centre of the Institution of Automobile Engineers.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—Much activity continues to prevail in the majority of the industries throughout the country, but one or two trades are suffering slightly from scarcity of raw material. A factor which may tend to cause a check to business is the exceedingly high prices to which everything has gone. Much new work was held back during the war years, and when the time for carrying some of the projects through seemed propitious a start was made, but delays in getting material, coupled with steadily rising prices, have told seriously all round. In one or two instances new work is being held back on account of the heavy costs and in the hope that a fall may come in the near future. Buyers seem convinced that prices must ease off, but there is as yet little indication in that direction, particularly in the iron and steel industries. There are plenty of orders for all classes of material, and wherever production depends chiefly on labour there can be little or no fall in prices in the meantime. Erection work which had got to the stage for the joiners to commence operations has had a serious check owing to the strike in that trade. As there seemed little prospect of an early settlement, many of the joiners have now gone south for employment. Through a dispute as to the method of payment all the platers' helpers on the Clyde are now out on strike, and some 6,000 men are involved.

Scotch Steel Trade.—The position of things in the steel trade of Scotland has not changed over the week, and all the works are as busily employed as ever. The shortage of raw material is still keenly felt, and production is therefore not as good as it might be under more favourable circumstances. The output is, nevertheless, on a large scale, and consumers keep pressing for deliveries, which, they say, fall far short of their requirements. It is an undoubted fact that the demand for steel for use at home was never larger than at the present time, nor of such a sustained character, and everything points to this state lasting for some time. The latest advance in prices may have some effect on buying, but so far the demand cannot be met, and those who hold off are only assisting those who don't because the probable date of delivery is still a long way ahead. Ship and boiler plates, as well as black steel sheets are all in great demand, and galvanised sheets are also in good request. Sectional material is a shade easier and delivery delay is not so pronounced. The export trade is not yet of any great volume. Steel scrap (heavy smelting) has been raised by 20*s.* per ton, and is now 11*l.* 10*s.* per ton, delivered works.

Malleable Iron Trade.—In the malleable iron trade of the West of Scotland there is still great activity, and makers are so fully supplied with orders that their output for some time is all earmarked. The home trade is consuming a very large tonnage of iron, and foreign inquiries are on quite a large scale. Strong prices rule, and no easing off is anticipated. "Crown" bars are being put through round 28*l.* per ton, for local delivery.

Scotch Pig-Iron Trade.—The most outstanding feature in the Scotch pig-iron trade is the continued scarcity of foundry iron and the enormous quantity being requisitioned by home buyers. None seem able to secure anything but quite a moderate percentage of their demands, and yet the tonnage being turned out is indeed very large. Under very difficult circumstances the makers are endeavouring to apportion their output to the best of their ability and so keep all customers moving. Similar conditions rule in regard to hematite iron, and very large quantities are being used in the various steel works despite the high price of 14*l.* 5*s.* per ton now asked. The home price for No. 1 foundry iron is from 13*l.* 10*s.* to 14*l.* per ton, while the export quotation is called 16*l.* 10*s.* per ton.

Sulphate of Ammonia.—The Ministry of Agriculture and Fisheries and the Board of Agriculture for Scotland have come to an agreement with the great majority of the makers of sulphate of ammonia with regard to the maximum prices to be charged for this fertiliser in the season 1920–21. These prices are the maximum net cash prices for sulphate of ammonia containing 24½ per cent. by weight of ammonia, in makers' 2-cwt. bags, delivered in quantities of not less than 4 tons to the purchasers or customers nearest railway station or wharf in Great Britain, or f.o.b. British port in the case of sales to Ireland, Isle of Man, or the Channel Islands, and are subject to a trade discount in the case of sales to manure mixers, agricultural merchants, dealers, and co-operative societies:—

Month of Delivery.	Price per Ton, in Bags, Net Cash. £	s.	d.
June and July, 1920	23	10	0
August	24	0	0
September	24	10	0
October	25	0	0
November	25	10	0
December	26	0	0
January, 1921	26	10	0
February	27	0	0
March, April and May	27	10	0

The other conditions of sale remain the same as during the past season, except that the additional charges authorised for each additional ½ of 1 per cent. of ammonia, for sulphate of ammonia containing less than 0·025 per cent. of free acid, and for sulphate of ammonia specially ground at the purchaser's request, have been raised to 5*s.* 6*d.*, 7*s.* 6*d.* and 7*s.* 6*d.* per ton respectively, and as the basis scale of prices now applies to minimum quantities of 4 tons instead of 2 tons an additional charge of 5*s.* per ton is authorised for deliveries of 2 tons and over, but less than 4 tons.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, May 28, at 7.30 p.m., in the Lecture Hall, Public Library, Plymouth, Inaugural Meeting of South-Western Local Section.

THE PHYSICAL SOCIETY OF LONDON.—Friday, May 28, at 5 p.m., at the Imperial College of Science, Imperial Institute-road, South Kensington, London, S.W. A discussion on "X-Ray Spectra" will be held, to be opened by the President, Sir W. H. Bragg, F.R.S.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, May 29, at 2 p.m., a General Meeting of the Associates and Students in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion: "Steam Economy," by Mr. Philip Kirkup, Junr.; "New Suggestions on the Prevention of Coaldust," by Mr. S. S. Chu; "A Few Notes on Coaldust Experiments," by Mr. R. W. Anderson. The following papers will be read or taken as read: "Practical Paper on Gob Fires," by Mr. William Leebetter; "The Electric Welding of a Corroded Boiler Shell," by Mr. A. K. Dawson.

THE SURVEYORS' INSTITUTION.—Monday, May 31, at 5 p.m., Annual General Meeting in the Lecture Hall, to receive the Report of the Council and the announcement of the result of the Election of Officers for the ensuing year.

THE INSTITUTION OF GAS ENGINEERS.—Tuesday, Wednesday and Thursday, June 1, 2 and 3, Annual General Meeting at the Institution of Mechanical Engineers, Storey's Gate, Westminster. The president, Sir Dugald Clerk, K.B.E., F.R.S., will take the chair. Tuesday, June 1, at 10.30 a.m.: Address by the president. Report of Refractory Materials Research Committee to be presented by the chairman, Mr. A. E. Broadberry: (a) "The Casting of Gas Retorts"; (b) "Some Comparative Tests of Machine-made and Hand-made Silica Bricks"; (c) "The Specific Heats of Refractory Materials at High Temperatures." Report of the Life of Gas Meters Research Committee: "The Internal Corrosion of Mains, Services and Meters," to be presented by Mr. J. G. Taplay, Chemist to the Committee. Report of Institution Gas Research Fellowship: "Some High Temperature Reactions of Toluene and Benzene," by Dr. S. F. Dufton and Professor John W. Cobb, C.B.E., B.Sc. Wednesday, June 2, at 10 a.m.: Annual General Meeting of the Benevolent Fund. After the meeting of the Benevolent Fund the Institution's Meeting will be resumed. Third Report of the Gas Investigation Committee. Thursday, June 3, at 10 a.m.: Paper on "Carbonisation," by the Society of British Gas Industries. "Oxygen in Gas Production," by Mr. H. J. Hodsman, M.Sc., and Professor John W. Cobb, C.B.E., B.Sc. "Electricity Supply by Gas Companies," by Mr. Joseph Fisher, of Tottenham. "Contemplations on the Report of the Fuel Research Board," by Mr. Godfrey Warburton, of Tottenham.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, June 4, at 9 p.m., the Friday Evening Discourse will be delivered by Sir Ronald Ross, K.C.B., K.C.M.G., M.D., LL.D., D.Sc., F.R.S. The subject is "Science and Poetry." Afternoon Lectures, at 3 p.m.: Tuesday, June 1, Major C. E. Inglis, O.B.E., M.A., on "The Evolution of Large Bridge Construction" (Lecture II); Thursday, June 3, Mr. William Archer, M.A., on "Dreams—With Special Reference to Psycho-Analysis" (Lecture II); Saturday, June 5, Mr. J. H. Jeans, LL.D., F.R.S., on "Recent Revolutions in Physical Science—(II) The Theory of Quanta."

GLASGOW SHIPBUILDING, ENGINEERING AND ELECTRICAL EXHIBITION.—An advance prospectus has been issued of a shipbuilding, engineering and electrical exhibition to be held at Kelvin Hall, Glasgow, from November 8 to December 4 next. The exhibition is promoted by the Corporation of Glasgow, and the general manager is Mr. James M. Freer, Kelvin Hall, in that city.

THE WILBUR WRIGHT LECTURE.—As mentioned on page 489 of our issue of April 9, the Wilbur Wright lecture will be delivered on Tuesday, June 22, at the Central Hall, Westminster, but the time has been altered from 8 p.m. to 8.30 p.m. The lecture, which is by Commander J. C. Hunsaker, U.S.N., is entitled "Naval Architecture in Aeronautics," and H.R.H. Prince Albert will take the chair. Members of the Royal Aeronautical Society desirous of attending and bringing friends, should apply to the secretary for tickets for reserved seats, which will be allotted in the order of application.

UNIVERSITY COLLEGE ENGINEERING FUND.—H.R.H. Prince Arthur of Connaught has received two important donations to the University College Engineering Fund from America, viz., 500*l.* from Mr. J. Pierpont Morgan and 500*l.* from Mr. E. R. Stettinius. Other donations received recently include: 250*l.*, Gas Light and Coke Company; 100*l.*, Mr. Percy Martin; 50*l.*, Igranic Electric Company, Limited; and 5,000 francs, M. C. P. Eugene Schneider. Also a promise of apparatus to the value of 50*l.* from Messrs. Nalder Brothers and Thompson, Limited. The total of the Engineering Fund up to date amounts to 32,375*l.* Further contributions are greatly needed in order to raise the fund as quickly as possible to 70,000*l.*, in order that the committee may avail themselves of the generous offer of a further donation of 10,000*l.* by Lord Cowdray. Contributions to the fund can be sent to H.R.H. Prince Arthur of Connaught at 42, Upper Grosvenor-street, W. 1, or to the Hon. Treasurer, Sir Ernest Moir, University College.

ENGINES OF THE MOTOR SHIP "NARRAGANSETT."

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page* 716.)

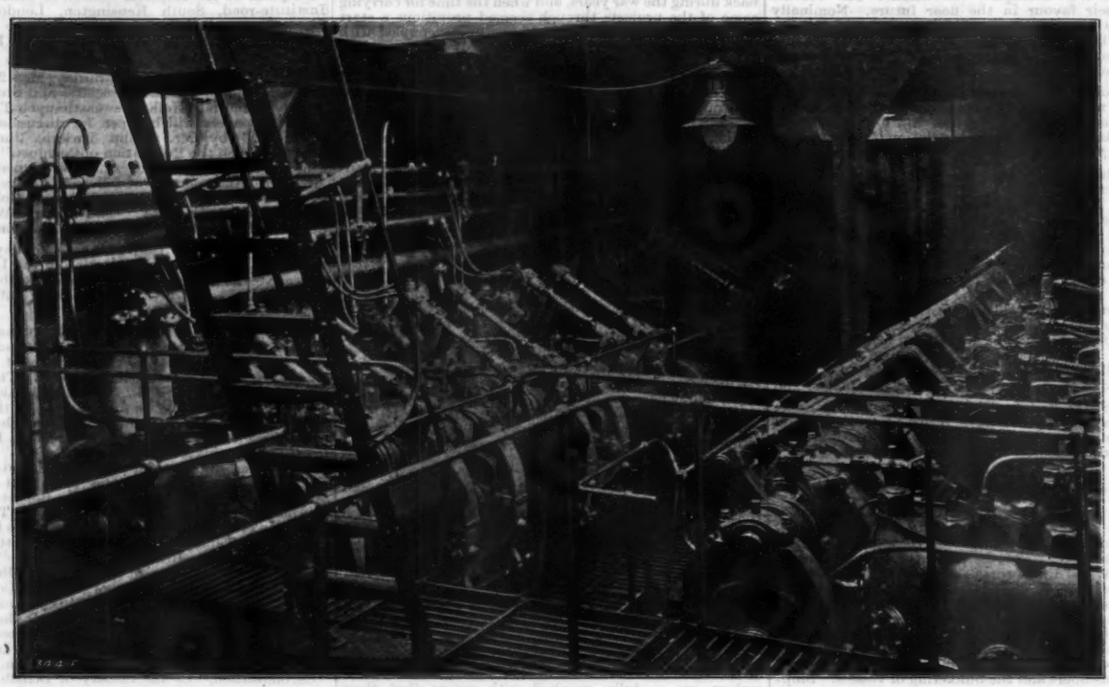


Fig. 16. Top Platform of Main Engines.

Fig. 17. Starting Platform for Main Engines.

MACHINERY OF THE MOTOR SHIP "NARRAGANSETT"

CONSTRUCTED BY MESSRS. VICKERS LIMIT

(For Descrip... see Page

Fig. 9.

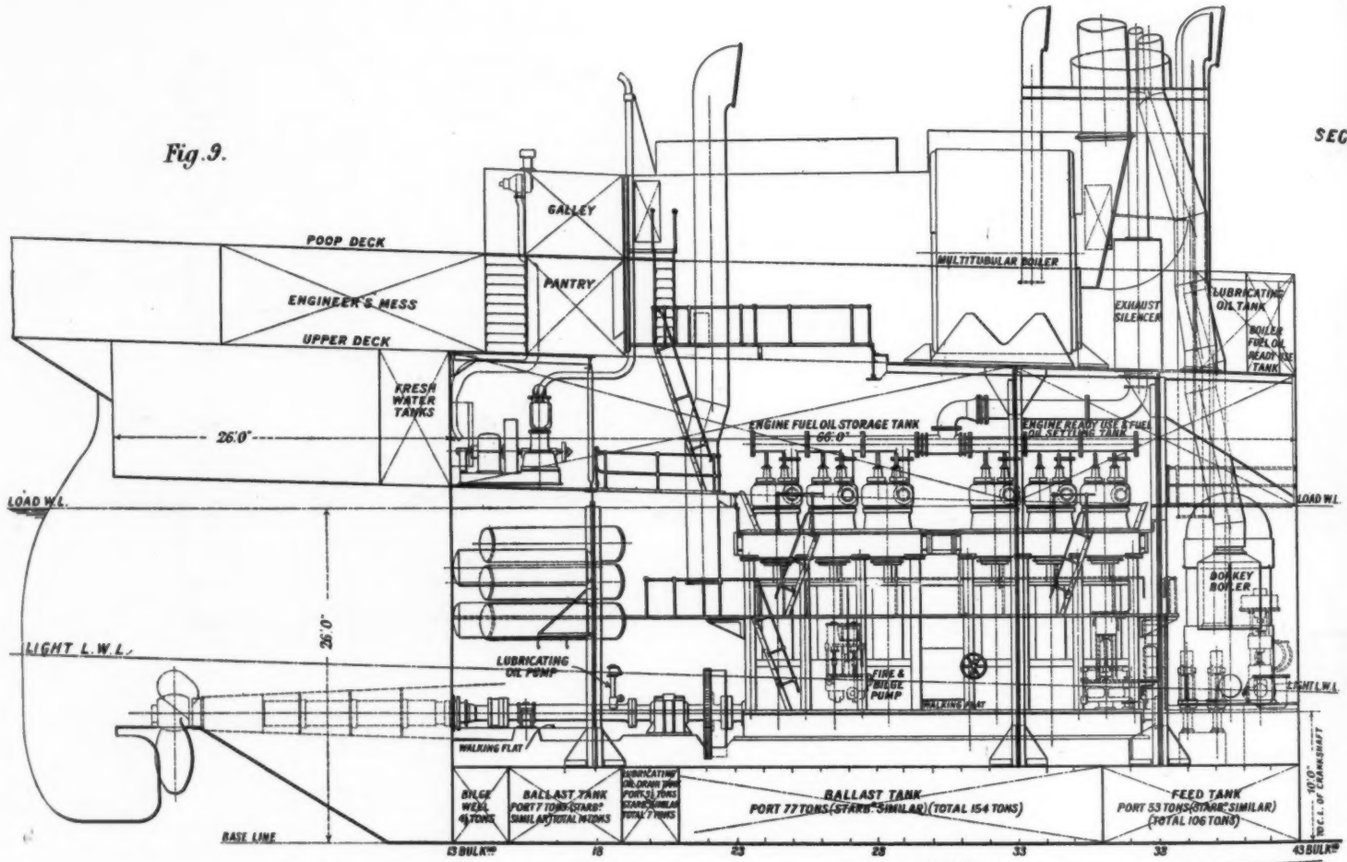
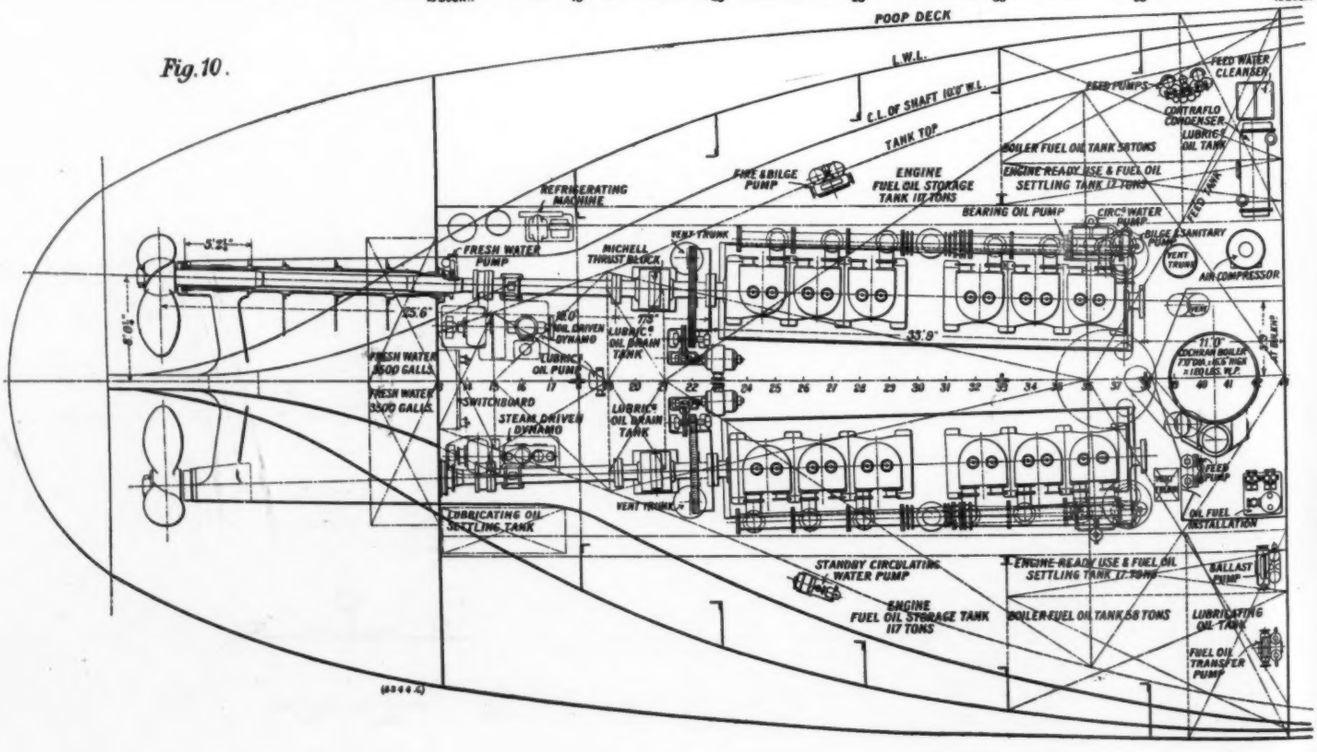


Fig. 10.



ANSETT" FOR THE ANGLO-AMERICAN OIL COMPANY.

VICKERS LIMITED, BARROW-IN-FURNESS.

(Description see Page 716.)

Fig. 11.

TION ABOUT FRAME 38
LOOKING FORWARD.

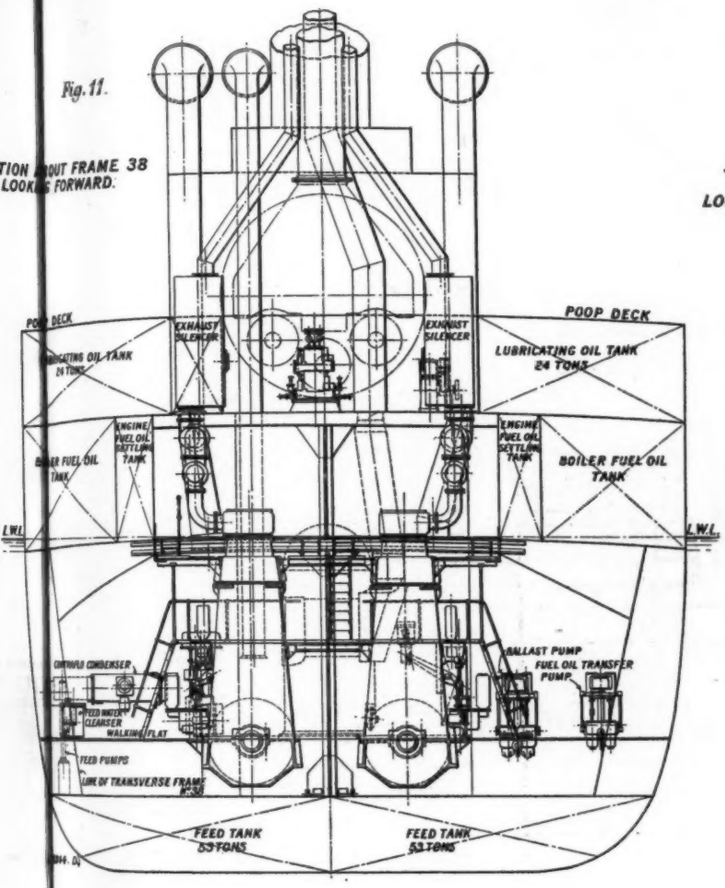


Fig. 12.

SECTION ABOUT
FRAME 23.
LOOKING FORWARD.

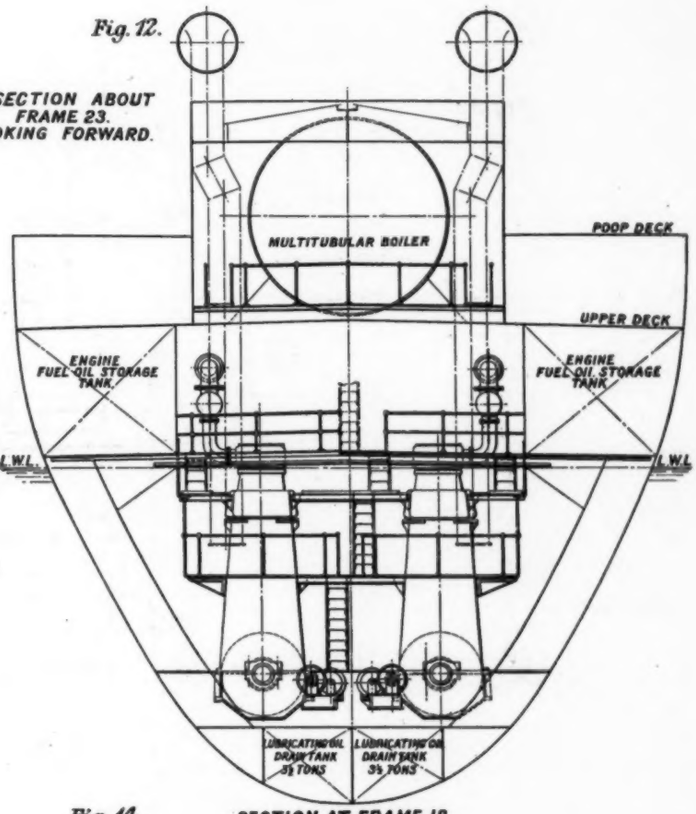


Fig. 13.

VIEW LOOKING ON UPPER DECK
IN WAY OF AUX. BOILER ROOM FLAT.

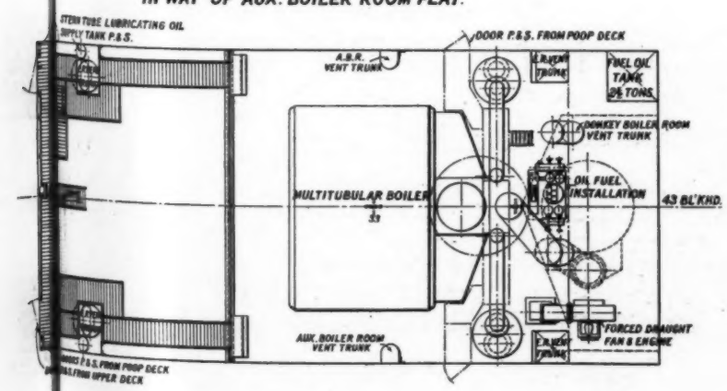
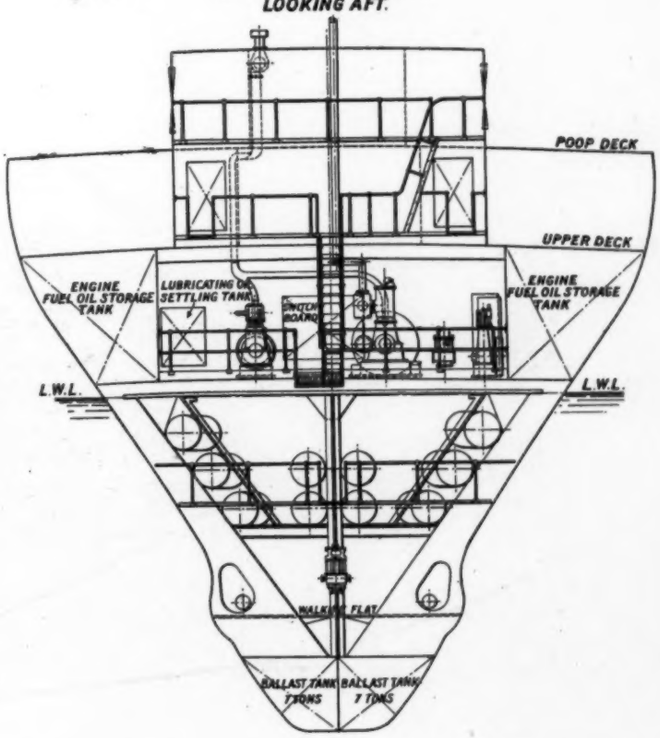

STERN TUBE LUBRICATING OIL SUPPLY TANK P.&S.
DOOR P.&S. FROM POOP DECK
A.S.R. VENT TRUNK
FUEL OIL TANK 24 TONS
DONKEY BOILER ROOM VENT TRUNK
MULTITUBULAR BOILER
OIL FUEL INSTALLATION
43 BL'KHD.
FORCED DRAUGHT FAN & ENGINE
AUX. BOILER ROOM VENT TRUNK
DOORS P.&S. FROM POOP DECK
DOOR P.&S. FROM UPPER DECK

Fig. 14.

SECTION AT FRAME 18.
LOOKING AFT.



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NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s. 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. So long as postal rates remain as at present there will be no increase in the price of copies sent by inland post, which will continue at 1s. 2d. post free.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of Supplies, Newsagents will not have copies for chance customers; therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 721.

ENGINEERING.

FRIDAY, MAY 28, 1920.

THE FUTURE OF INDUSTRY.

KINGSLEY commenced his delightful, if not wholly trustworthy, lectures on the Roman and the Teuton by a parable in which he likened ancient Rome to a fairy palace or garden situated in a primeval wood. Inside the palace dwelt the Trolls watching their fairy treasures and by their cunning constantly creating fresh wealth. Outside the garden lay another race, poor and quarrelsome, and learning every day more and more of the wonders of the fairy palace. Finally they break in and master the owners, but the fairy wealth has disappeared no man knows where. The conquerors captured all that the vanquished possessed save their cunning, and in this instance the word should retain its primitive meaning of "know how," and without this purely immaterial possession all that remained to the disappointed invaders were a few petty spoils. For many decades past the proletariat has been fed by our modern materialists on fairy tales as to the immense treasures that are to become theirs by the mere process of seizure, but were the socialisation of industry effected, triumphant democracy would undoubtedly suffer a disillusion as astonishing as that encountered by the tribes which captured Rome. This, indeed, is precisely what has happened in Russia, where the wealth seized by the Bolsheviks disappeared for the most part in the very act. Thus from a comparatively rich and prosperous country that immense Empire has been reduced to a state of abject poverty, in which no one save a few officials can attain to more than a most meagre subsistence allowance, as his reward for compulsory labour enforced for 12 hours a day.

The creative mind, in short, to which every great increment of wealth can be traced, fits in badly with either a communistic or a co-operative scheme of society. The man of genius is ever and necessarily an individualist.

We need not, however, go so far as Russia for evidence that the value of an undertaking is apt to diminish when its control is transferred from experts to the community, which in practice means to politicians and bureaucrats. In the exceedingly interesting and informing address to the employees of the Allgemeine Elektricitäts Gesellschaft of which we conclude the publication this week, Mr. Felix Deutsch observes that during the four years before the war the Berlin Electricity Works distributed to the shareholders some 6,129,000 marks annually. The city having a first charge of 10 per cent. on the gross profits received from 3,500,000 marks to 4,000,000 marks annually, whilst in other taxes the company contributed annually to public purposes another 3,000,000 marks. It thus appears that the share of the community in the profits of this undertaking exceeded by one-sixth that of the shareholders, and it should be noted that the public charges were first charges on the undertaking, although the public took none of the risks. Nevertheless the city having got much, desired more; and decided accordingly to acquire the undertaking. The result was an immediate fall in the profits, which continued, and has ultimately led to the complete disappearance of all return to the new owners. Of course, the conditions have been abnormal during the past few years, and were it not that the experience has been frequently paralleled here and in normal times, it would be unfair to quote it as an example of the futility of socialisation. Telegraph profits it will be remembered disappeared rapidly after being taken over by the State. Again, some fifteen years ago, a large borough in the London area refused to renew a lease of their tramways undertaking to the company then working it, in spite of the very liberal terms offered. The liberality of these terms was, in fact, used as an additional reason in favour of getting rid of the company, as it was argued that the profit on working must be extraordinarily high to have made such proposals possible. The actual result of municipal management was the rapid disappearance of all profit whatsoever. A non-material something had disappeared with the transfer from private to public control, and with it vanished the anticipated large relief to the rates. Of course, had the town in question been situated outside the London area a nominal profit might have been secured (as is done in Manchester, Glasgow and other provincial cities), by denying to the public the advantages of novel and improved methods of transport, but it can hardly be doubted the loss to the public in those cities, thus occasioned, far exceeds in value the relief to the rates secured by this shortsighted policy. When, as in the London area, it is impracticable to establish a legal monopoly of transport, the cry of the social reformer is for what that self-constituted authority on the principles of mechanics and on transportation, the late Sir Lawrence Gomme, called the "organisation of the traffic." This put into plain language means that when the railways were first introduced the traffic should have been so organised as to keep the stage coaches permanently in service.

Whilst, as repeated experience has shown, the socialisation of an industry retards or inhibits the creation of wealth, it may be observed that under our present system of industrial organisation the proportion of the total profits taken by those who provide the ways and means is but a small fraction of that secured by the operatives employed. Some interesting figures on this head were afforded by the census of production taken in 1906. From the returns there made it appears that in the engineering trades the capital investment averaged some 180*l.* to 200*l.* per employee, and the average dividend did not exceed some 4½ per cent. to 5 per cent. It is this small percentage that constitutes the fairy wealth that the proletariat is urged to seize, and which, if it attempts to take, will disappear in the process. It amounts in all to some 9*l.* to 10*l.* per head, and this figure is singularly confirmed by corresponding figures for Germany given by Mr. Deutsch. He states that the average return before the war on the capital of industrial concerns quoted on the Berlin stock exchange did not exceed 6 per cent., although only thoroughly sound concerns were admitted to quotation. Some 66 companies with, in the aggregate, 783,781 employees, paid over 10 per cent., and Mr. Deutsch has been able to secure full data as to the distribution of the profits made by these exceptionally profitable undertakings. Of this total, salaries and wages took 76·7 per cent.; rates and taxes, 11·7 per cent.; and the shareholders, 11·6 per cent. If the whole of the proportion taken by the latter were distributed amongst the employees the amount received would have been 250 marks per head, or about 12*l.* 10*s.* In view of the exceptional prosperity of these companies this figure is in good agreement with that derived from a study of the British census returns. If, however, we reduce it in the proportion of 6 to 13, that is to say, in the proportion of the average dividend to the exceptional dividends paid by these particular companies, the maximum possible gain would amount to no more than some 6*l.* per head per annum, a margin which would

rapidly disappear when the control of experts was replaced by that of a committee of politicians.

Of course, as Mr. Deutsch points out, the amounts received by the shareholders is the residue available for distribution, and does not include the sums carried to reserve. These reserves are essential to the continued prosperity and extension of a business, and when re-invested in it yield a return of which labour takes over three-fourths, the State and municipalities at least an eighth, whilst from 1 per cent. to 3 per cent. should be expended in research, so that the final benefit accruing to the shareholder is far from extravagant. The accumulation and expenditure of reserves on the extension of a business is essential to its continued growth and prosperity, and from this point of view there is much to be said in favour of the plan of taxing (in normal times) only the sums distributed as dividends, since in the ultimate the nation profits far more by the extension and development of a business than it does by sweeping into the Exchequer part of the undivided profits. Ploughed into the business the latter will produce new dividends from which the nation will take its toll and at the same time employment will be found for additional officials and workmen, each of whom will also contribute to the revenue by direct or indirect taxation.

In the concluding portion of his address, Mr. Deutsch gives some interesting details of the methods by which the manufacturing industries of Germany were raised from comparative insignificance in 1880 to the prominent position they held in 1914. Speaking broadly, the policy pursued has been one of payment by results. Ability, wherever found, received an exceptional award, and the whole spirit actuating the control was, as far as possible, removed from the deplorable attitude adopted by too many British manufacturers in regard to their technical assistants. Carnegie showed years ago, that it paid to reward technical ability liberally, and the German experience fully confirms this. The German chemical manufacturing firms have, as well known, speculated largely in research, but they have not taken the line common here, that having provided the apparatus and plant, the successful investigator should receive no reward beyond his fixed salary. It augurs badly for the future of British industry, that this latter viewpoint still appears to be that which commends itself to British manufacturers, as was clearly evident in the conference held last year between the "Advisory Council" and the representatives of a large number of trade organisations. One speaker took the view that no employee was entitled to patent any idea that occurred to him in connection with his employers business; such he seemed to assume belonged of right to the employer, a position which is not only ethically indefensible but the extreme of unwisdom. It seems impossible that any employer can really benefit by so short-sighted a policy. No workman or other employee will worry out new ideas of value, if he is assured beforehand that he will receive no adequate reward for his creative thought. This kind of employer escapes, no doubt, the pain of paying out a royalty to a mere manager, draughtsman, or workman; but in this saving at the spigot, he loses infinitely more by the curious dearth of new ideas, which comes to characterise his business, and by the loss of the most able of his men to other and more farsighted concerns. These fortunately exist, as was shown by the cases cited in Mr. J. Hamilton Gibson's recent address to the Institution of Marine Engineers. The experience of the German manufacturers who appear to have adopted a similar enlightened policy, goes to show that honesty may well prove the best policy in regards to creations of the mind as it undoubtedly is in matters of material.

ROADS AND TRANSPORT IN INDIA.

THE time was when India possessed some of the finest roads in existence. To-day many of them have disappeared and long lengths even of the main trunk roads are impassable—parts have returned to jungle, bridges have been subverted to other services, and in several cases have actually vanished. This astonishing record of enlightened policy on the part of the Government of India was the subject of a very interesting paper read by Lord Montagu of Beaulieu on Thursday the 20th inst. at the Royal Society of Arts. As Adviser on Mechanical Transport Services in India the author has had ample opportunity of becoming acquainted with the actual state of affairs. A confirmed advocate of motor vehicles, Lord Montagu might have been expected to express himself in much stronger terms than he actually used. His facts are undeniable and constitute a serious impeachment against the Government of India.

It is well known that in India the Government is directly interested in the railways. For this reason, it has been argued, they have allowed what was once a good system of roads, with certainly first class trunk roads, to be neglected, in order to encourage traffic to the railways. Formerly the roads were essential to the movement of troops—it is now considered that these can be better transported by rail. Provided the line is secured railway transport is certainly much more effective. It was pointed out, however, in the discussion that the railways of India are very vulnerable indeed and that in any serious trouble in the country they would be liable to easy interruption. No one who knows anything of India and the way the railways are worked there will doubt this, and will recall innumerable points where they might be cut, all of which it would be impossible to guard adequately. Yet in spite of this the roads, the only alternative, have been allowed to get into a state of disrepair. In fact, they have proved of so little interest to the Government that it is twenty years since the last returns and statistics concerned with them were drawn up.

Distances in India are great, and it would not always be possible to use road transport to supplement the railways, but when it is pointed out that during the Afghan war of 1919 a truck of army supplies took three months to get from Karachi to Peshawar, it may almost be asked if road transport could possibly have done worse. This journey was over a single system, and not over a route involving running over various railways, when some delay is often excusable. The operations of 1919 were on a much larger scale than is generally realised, and the railways had to handle unprecedented traffic at a time when they were suffering seriously from the effects of the war of the previous years. The road transport available was at the time more than occupied with work beyond railhead. The combination of circumstances was against efficient transport.

A good deal was heard in England of the breakdown of the roads under the motor transport used in this frontier war. It has to be remembered that these roads, many of them without good surfaces to start with, were called upon to withstand very heavy traffic indeed all through the summer. Although repairs were put in hand it was in many cases almost impossible to carry them out as well as desirable. In the first place the repairs had to be executed in the middle of the hot weather, when, up the passes where there is no water, the material cannot be thoroughly consolidated. In the second place the repair material was limited, on account of lack of transport and labour, to what was near at hand. While in places this happened to be fairly good, in others it consisted of a flakey shale, the pieces of which simply slid over each other until powdered to dust. Once the roads had succumbed to the heavy motor traffic it was therefore all but impracticable to renovate them thoroughly during the actual military operations.

Lord Montagu points out the need for lateral roads along the frontier. At present to get from one area to another, a journey has in cases to be made many miles back to a junction point and then out along another radiating road, involving two sides of a very long triangle. Lateral roads with branches up the valleys would greatly facilitate operations. It is to be hoped, of course, that road building in these corners of the earth will tend as it has elsewhere to hasten the march of civilisation and order, and that they will become eventually highways for commerce rather than military necessities. We pay annually large sums to these frontier tribes if they behave themselves and do not raid and otherwise make trouble. How much better it would be if the policy were more constructive, and an equal amount of money distributed to the tribes by way of payment for road-making.

It is doubtful whether frontier roads can ever be made dustless, however desirable that may be from the point of view of military operations. The clouds of dust raised by motor transport are, it must be admitted, a veritable danger on the hill roads, while the discomfort to marching troops is enormous, but the idea of tar-spraying would seem almost out of the question though it might be adopted more frequently in cantonments. Where a whole country is dusty, as it is in parts of India, it is too much to hope that the roads can be kept free of this trouble though tar-spraying where feasible might reduce it.

THE THERMOIONIC TUBE.

THE thermoionic tube or valve has become an instrument of such wide utility that the lucid exposition of its principle, which Professor W. Eccles, D.Sc., of Finsbury Technical College, gave last April in two Royal Institution lectures on "The Thermoionic Tube as Detector, Amplifier and Generator of Electric Oscillations" will be welcome to our readers. Every substance, he explained, emits electrons when heated. The mechanism resembles that of ordinary evaporation; but the electrons carry electro-negative charges, whilst the evaporated molecules are uncharged. The phenomena are complex in gaseous atmospheres, but simple in high vacua. When we apply an electromotive force E.M.F. to two electrodes facing one another and heat the cathode, a stream of electrons will flow from the cathode to the anode, *i.e.*, in the opposite direction to the old conventional current (see Fig. 1 and also Fig. 2, on the opposite page), the thermoionic current rising as we raise the temperature in a steep curve (Fig. 3). A heated tungsten filament will hardly emit electrons below 2,000 deg. C.; above 2,000 deg. the current increases rapidly, reaching at 2,500 deg. 200 times its value at 2,000 deg. In the Fleming valve or diode the anode is a cylinder surrounding the tungsten filament of a lamp, and the diode is used as rectifier, the current travelling only in the direction mentioned. Dr. Eccles exemplified this by reversing the key in the battery circuit by hand, about five times per minute, when the galvanometer deflections were always to the right—never to the left. Since now the current is carried by the small electrons, practically devoid of inertia, the valve can likewise rectify currents of 10,000,000 reversals per minute. But the curve of Fig. 3, which turns level, and Fig. 2, will help to show that temperature and electromotive force applied have to be adapted to one another. With a low E.M.F. of 55 volts, *e.g.*, the current will cease to increase when we raise the temperature above a certain value, of 2,300 deg.; we pass then to the flat maximum of the curve. It is true that we can liberate more electrons by heating the filament to a higher temperature. But these electrons are not emitted at high speeds; they gather near the cathode and, being all electro-negative, repel one another, so that their further liberation is stopped. This "space charge," due to the neighbouring electrons, will not shift a particle midway between the electrodes, but will tend to drive an electron near the cathode back into the cathode, and drive another one near the anode upward towards it (Fig. 2), unless we overcome this space charge by applying a stronger E.M.F. The more positive we make the upper electrode, the more the zero position (between the electrodes) will be shifted towards the cathode. Starting with a battery current of 150 volts, Dr. Eccles could reduce the volts to 52, without diminishing the galvanometer deflection by more than 2 divisions, from 25 to 23. That showed that the current was on the level portion of the curve (Fig. 3) in the saturated condition, in which all the electrons emitted are utilised. A valve used in this condition served as a limiting device safeguarding the apparatus to which it was coupled; the current would not rise above the maximum corresponding to the level portion of the curve. To make the valve more sensitive to fluctuations in the E.M.F., we should try to work on the rising straight portion of the curve, a result which in this case, the lecturer remarked, would be obtained by raising the temperature of the filament.

The value of the straight curve was, however, better seen in the case of the triode, which contained a third electrode, the "grid," between the anode and cathode. The grid may be a wire bent to the shape of a grid, or a spiral, surrounding the filament. The diagram, Fig. 4, shows the parts of the triode [within a circle] and the rather complicated connections. The upper electrode, the anode, is joined to the main battery, and this circuit is known as the anode or plate circuit; the grid is indicated by the dotted line; the cathode or filament circuit comprises the small battery heating the filament. When the grid and anode are directly connected the triode becomes a diode. The advantage of the grid is that it enables us to alter the space charge. When the grid is made positive, it eliminates the repulsive force between the electrons, facilitates their emission and increases the current; when made negative the grid reduces the emission and the current is decreased, the point being that one grid volt is able to cancel x plate volts, the x increasing as the grid is approached to the cathode.

With the aid of a galvanometer in the external circuit, Dr. Eccles demonstrated that the addition (or cutting out) of one dry cell to the grid circuit had the same effect as the addition of 6 cells to the plate circuit. The triode, he said, was used for the amplification of the current input on the constant-current system, the constant voltage system, or (more generally) by combinations of the two systems. By coupling 20 triodes in cascade, each giving an ampiification of 10, the total magnification obtained would be 10^{20}. The regulation could be effected by transformers as well as by resistances, the coils acting largely as choking coils. Since the grid required little current to feed it, the triode was very convenient to get over the difficulties of bad contacts. Dr. Eccles exemplified this by an experiment ascribed to Edison. A contact is made by approaching a lighted cigar or match to a strip of ebonite which bends under the influence of heat; the effect was much more striking when a triode was joined to the circuit. A radium clock afforded another illustration of the power of the triode. In this device (due to the present Lord Rayleigh) a small radium tube and a small metal-foil electroscope are enclosed in an evacuated bulb; the radiations charge the electroscope, the expanding leaves of which touch contacts in the bulb; when one of these contacts was joined to an amplifier, the discharge became audible.

Since the expenditure of small energy in the grid circuit liberates large energy in the plate circuit, the triode can also be utilised in controlling devices. A master pendulum inducing minute current oscillations in the grid circuit can sustain the oscillations of another pendulum of the same period through the aid of an electromagnet in the plate circuit. Fig. 5 illustrates a novel alternating-current motor of Dr. Eccles, based upon this principle. There are two electromagnets, I in the grid, II in the plate circuit; between them rotates an ebonite wheel set with contacts or teeth. When the motor is turned and a tooth approaches I, the current induced is magnified in II, enabling II to pull the next tooth round; the effect is repeated when a tooth recedes.

The small motor exhibited was not self-starting, but when brought up to speed by hand it keeps its speed, and Dr. Eccles has found it very convenient for producing currents, of variable, but constant frequency for testing purposes; the alternating currents may be branched off from terminals in the plate circuit or from a transformer coil. The motor is probably the first of its kind working without slip rings or commutator; the sparking of the commutator would seriously interfere with any delicate testing of high-frequency apparatus.

In another device Dr. Eccles had replaced the motor wheel by a tuning fork, electromagnet I being above the one prong, II below the other. But any oscillating device may be coupled with a triode to produce amplified electric oscillations, and Fig. 4 already mentioned exemplifies the connections of a coil for this purpose. The ends of the coil are joined to the grid and the plate circuits, the middle of the coil being connected to the filament. The oscillations act upon the grid and are themselves acted upon by the fluctuating plate current. There was no outward sign that Dr. Eccles' coil was really oscillating. To prove it, he approached a similar coil circuit, containing a crystal detector (serving as rectifier for the induced currents) and a galvanometer.

Of more practical interest was the other demonstration by the "heterodyne or beat method." When two oscillating circuits are tuned to nearly the same frequency, 500,000 oscillations per second the one, 500,100 oscillations the other, the second circuit comprising a rectifier and a telephone, the telephone will give the difference (or beat) note of $d = 100$ oscillations per second. It is essential that the currents should be rectified as well as amplified, and that is secured by the arrangement illustrated in Fig. 6. The additional devices shown are (apart from the telephone) a small condenser and a high

TRIODE OSCILLATION SET.

Fig.1.

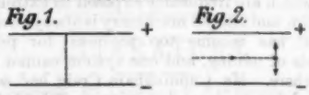
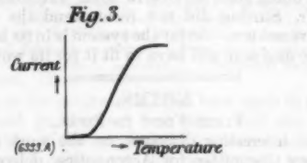


Fig.2.

Fig.3.



OSCILLATION WITH CUMULATIVE RECTIFICATION FOR BEAT RECEPTION.

Fig.4.

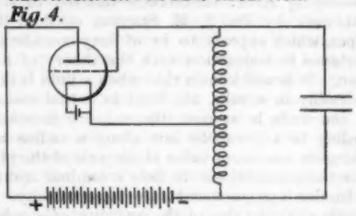


Fig.5.

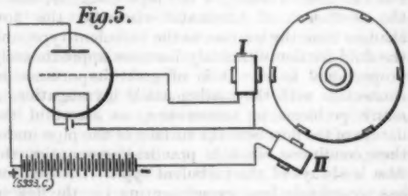
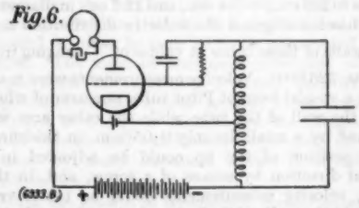


Fig.6.



resistance in shunt to it, both in the grid circuit. Electrons can accumulate in the condenser only when the grid is positive; that accumulation, however, turns the grid negative and would diminish the plate current, if the resistance mentioned, the "grid leak," did not allow the negative charge to escape so that the plate current can rise again. The frequency of the oscillations now can be varied by altering the capacity. When the frequency difference d amounts to thousands of oscillations per second, no sound will be heard; as we increase the capacity in the one circuit, the d will decrease, and the sound will become audible; when we come down to $d = 30$, the sound will be inaudible again. The audibility will depend upon the listener and his age and upon the kind of telephone, and the listener can adjust the pitch to his own liking. If we increase the capacity beyond the perfect tuning adjustment where $d = 0$, the sound intensity will become stronger again, and the position intermediate between the positions of maximum intensity will mark the capacity for perfect tuning.

The extraordinary sensitiveness of such oscillating coils, especially if of small dimensions, to intentional or accidental slight changes in the capacity or inductance was demonstrated by Dr. Eccles, and its various utilisations were explained. When a piece of apparatus or simply a piece of wire, particularly if forming a closed ring, was brought near one of the oscillators the pitch of the telephone hum at once changed; even the mere movement of the hand of the experimenter had a pronounced effect. When radiotelegraphic appliances are coupled for heterodyne receiving, it may hence be sufficient to give Morse signals by moving a small wire loop instead of working the key. On the other hand, such a pair of oscillators can serve as a delicate induction balance. A small loop of copper wire had a stronger effect than a loop of iron wire. Taking a condenser made up of two vertical zinc plates standing in a glass cell, Dr. Eccles held an open bottle containing ether over the cell; the sinking vapour (heavier than air) affected the capacity and the note. The insertion of a piece of ebonite or paper, or of a gas flame between the condenser plates would produce similar or opposite effects. The thermoionic valve works with electrons. From the energy point of view it is still very inefficient; but it does wonderful things by simple means.

THE AIR-LIFT SYSTEM OF RAISING OIL.

THE air-lift system of raising liquids which Pohle introduced about thirty years ago for dealing with water in the first instance, and which he himself later tried on oil, works with compressed air, but must be kept distinct from pumping by means of compressed air. When Mr. W. H. Maxwell described in 1903* the air-lift pumping plant which he had installed at Tunbridge Wells, he gave his paper the title: "Raising Water by Compressed Air," and the protracted correspondence on air-lifts which followed the publication of this communication in our columns proved that the principles of the air-lift were not always clearly understood. When the liquid level in a well is too low to admit of voluntary flow, the level can be raised by introducing compressed air into the liquid; the mixture of air and liquid is lighter than the liquid alone, and the hydrostatic pressure in the strata can balance a higher column of the mixture than of the liquid. In this way 50 oil wells at Baku, which had been abandoned or could only be worked by baling, were, in the first years of this century, made to yield for long periods much more oil than the previous baling had produced. Encouraging results were also obtained later in Trinidad and in some other oilfields. Yet the system has not developed, and when the Institution of Petroleum Technologists devoted the concluding meeting of the session on May 18 to a discussion of "The Air-Lift System of Raising Oil" in connection with a paper by Mr. Robert Stirling, the advocacy of the system met with more criticism than support.

Mr. Stirling writes from long experience both in Baku and in Trinidad. Perhaps he was partial when he declared the air-lift, properly applied, to be the most advantageous means of raising the oil from all wells yielding sufficient liquid for the continuous working of an apparatus of the smallest practicable capacity, particularly in the case of wells which have ceased to flow naturally or discharge only intermittently. But the system certainly has advantages. The plant is simple generally; it dispenses with derricks, can be adapted to wells of any shape or dimensions, and admits of centring the machinery, and, if Mr. Stirling had himself been present at the meeting—he was unable to attend—he might have refuted some of the criticisms made

Mr. Stirling admitted that the system requires constant, careful and judicious supervision. When the outbreak of the war between Japan and Russia had dispersed the trained staff at Baku, and the new oil engineers seemed to believe that the simple system might be worked with almost any equipment, peculiar difficulties crept up. The air is introduced, generally at the bottom of the well, either through a central pipe so that the mixture rises in the annular

* See ENGINEERING, November 13, 1903, page 675.

space between the air tube and the drilling tube or the casing, or the air feed is lateral and the discharge is through a central tube. The tubes must be able to withstand a pressure of at least 200 lb. per square inch and in some cases twice that amount.

All the wells, fifty in number, mentioned in the paper, were either damaged or flooded with water; but the air-lifting did not cause further damage. In the first well experimented upon, 1,358 ft. deep, the oil stood at 600 ft. from the surface, and greater lifts were subsequently dealt with. On the other hand the increased flow will lower the oil level, and might cause a defective casing to collapse; Mr. Stirling did not know of any such case, however.

The misapprehension also seems to exist that the compressed air and the weight of the higher liquid column would drive the oil back into the oil sands or other strata. But water and sand can, of course, gain access together with the oil, and the conditions may favour the discharge of either oil or water. In one case mentioned the water was presumed to come in at the bottom of the well, and the oil at a higher level through a defect in the casing. A packer was placed near the well bottom; the water was kept out, and the oil output greatly increased, though the oil level in the casing went down several hundred feet. The water may cause serious trouble, however, when churned by the air with the oil. An oil emulsion may then be produced from which, especially if the water percentage be within 5 or 20 of that of the oil, the oil will not settle subsequently. This difficulty can be overcome by running more water into the oil. But when the conditions change several times within an hour, which may happen as Mr. Beeby Thompson remarked, even a resourceful engineer may not be able to adapt the aeration to the fluctuating conditions. Highly ferruginous water, moreover, deposits iron hydroxide on the pipe walls when aerated, another trouble with which Mr. Beeby Thompson had been confronted in Baku.

Then the sand enters together with the oil. The sand cannot be kept out by screens because the packing of oil and mud forming on the outside of the screen would soon become impermeable to the oil. The accumulating sand has to be removed by the special sand pump, or sand corks are blown out occasionally by the aid of compressed air, at considerable risk to the well. Sand eruptions are very common in Trinidad and, as at Baku, oil wells which ceased to yield after sand ejections were considered to be exhausted, whilst in reality the capping material, frequently a clay, had fallen in and dammed the oil off. The air-lift stirs the sand up; but when the system was adopted in Trinidad, Mr. Stirling stated, it was unfortunately with unsuitable apparatus. In one of the early plants the air-lift failed after a time, and the withdrawn drill stem was found to be perforated in places corresponding to the standard pitch of the perforations. When the liquid level was lowered, the oil and sand grains from an upper-soil sand, had been forced, with the gas, through the perforations with such a velocity as to create a sand blast. An improvement was affected by making the perforations ($\frac{1}{2}$ in. diameter, 6 in. pitch) larger or closer so as to provide a free passage for the oil. But it had already been learned at Baku that a foot valve should be added to the bottom of the tubing. Mr. Stirling fits this foot valve to the drill stem of the rotary system with which the air-lift system is generally combined. The foot valve admits of drilling into an oil sand containing gas under high pressure so that the oil flow, when permitted, is not interrupted by the choking of pipes. Mr. Stirling's patented device of 1917 was intended for machinery in which the discharge pipes is surrounded by the drilling tube, and the latter by the casing. Above the drilling bit, at the bottom of the drilling tube, is first a back pressure valve and above this the foot valve into which the discharge tube is screwed; the valve allows the oil to enter the discharge pipe when a covering piece is raised above a slot and some perforations. His latest devices comprise an air regulator; a meter valve, to regulate and to distribute the air; an air nozzle screwed into the discharge pipe at a suitable depth below the liquid level; a supplementary starting nozzle, and the foot valve, which consists of a perforated casing and a movable perforated sleeve inside it, attached by a conical screw to the discharge pipe. The special starting nozzle is used to obviate the necessity of having to maintain a much higher air pressure for starting the flow than is required for pumping.

The gas in the oil facilitates the lifting, but it may also endanger the use of the gas as fuel for gas engines. Mr. Beeby Thompson referred to a bad explosion of this kind. To avoid explosions, Mr. Butterfield inquired whether it would not be possible to aerate with the gas itself, in a kind of closed circuit. That sounds hardly possible, and it would not meet one other objection to the aeration process, that the expanding gas cools the oil and this may lead to solidification of the paraffin in the oil. High-pressure air pipes are not liked in oilfields, moreover, which are frequently exposed to extreme heat and cold, and simple machinery is always desirable. But oil has become too precious for primitive methods of mining, and one system cannot answer everywhere. Mr. Cunningham Craig had seen the air-lift doing good service in some Trinidad wells, and Mr. Stirling did not recommend the system for universal use. So far the system is in its infancy, and the engineer will have to fit it for its work.

NOTES.

FLUID FLOW IN PIPES.

IN an interesting discourse on the work of the Advisory Committee for Aeronautics, delivered at the Royal Aeronautical Society on Wednesday last, Professor Sir R. T. Glazebrook referred to some recent work by Dr. T. E. Stanton on fluid flow in pipes, which appears to be of very considerable importance in connection with the theory of fluid motion. It is well known that when a fluid is flowing steadily in a tube, the fluid in actual contact with the walls is at rest, the velocity increasing according to a parabolic law along a radius and reaching its maximum value at the axis of the pipe. Under these conditions the flow is laminar and the fluid friction is proportional to the mean velocity. At a certain critical value of the quantity vd/ν, where v is the mean velocity, d the pipe diameter, and ν the coefficient of kinematic viscosity, the flow changes from the laminar to the turbulent type, and the fluid friction ultimately becomes approximately proportional to v^2. It is of great importance in connection with the mathematical investigation of many problems in aeronautics, to ascertain the nature of the flow near the surface of the pipe under these conditions, since, in practical aeronautics, the flow is always of the turbulent type. Dr. Stanton has accordingly been experimenting on the flow in tubes 0·269 cm., 0·714 cm., and 12·7 cm. in diameter, and has investigated the velocity distribution near the walls of these tubes at values of $\frac{vd}{\nu}$ ranging from 460 to 325,000. Velocity measurements were made with a special form of Pitot tube, one arm of which was the wall of the tube while the other arm was formed by a small lip only 0·05 mm. in thickness. The position of the lip could be adjusted in a radial direction by means of a screw, and, in this way, velocity measurements could be taken very close to the walls of the tube; in one series of readings with the 12·7 cm. pipe the position of the centre of the Pitot tube ranged from 0·013 mm. to 0·178 mm. from the wall. From the results obtained it seems certain, at all events for the range of $\frac{vd}{\nu}$ taken, that there always exists near the wall of the tube a very thin layer of fluid in which the flow is laminar. The velocity over the walls is zero, and the friction is given by the limit of the quantity $\mu\frac{dv}{dx}$ when x is zero, x being measured at right angles to the surface. This result is extremely interesting, and is of very great importance in connection with the theory of fluid motion as applied to aeronautics, as it establishes the conditions which must be assumed to hold at the surfaces of aircraft.

SUMMER MEETING OF THE NAVAL ARCHITECTS.

The Council of the Institution of Naval Architects, and Mr. Dana, the Secretary, are to be congratulated on the programme which has been provisionally made for the Liverpool summer meeting which opens on July 6 next, when the members will be received by the Right Hon. the Lord Mayor of Liverpool in the Town Hall. Following this, two papers are to be read, one by Sir Norman Hill, K.B.E., on "The Functions of the Merchant Ship," and the other by Professor J. J. Welch, on "Some Features in the Design and Construction of Mercantile Vessels considered in the Light of Recent War Experience." In the afternoon the members will visit the extensive works of Messrs. Cammell, Laird and Co., Limited, of Birkenhead, and will be entertained to lunch by the firm. In the evening a reception is to be held. On Wednesday forenoon there are down for discussion three papers, again on important phases of merchant shipbuilding. The first is by Sir Westcott S. Abell, K.B.E., M.Eng., the Chief Ship Surveyor of Lloyd's, who will deal with the "Safety of Life at Sea," while Mr. George Webster has for his subject the "Subdivision of Passenger Ships," and Mr. C. Frodsham Holt, M.Eng., will contribute the third paper on "The Efficiency of Propulsion of Full-Sized Ships." In the afternoon the members will visit the Port Sunlight Works, on the invitation of the Right Hon. Lord Leverhulme, and in the evening the Institution Dinner will be held. It is appropriate that on Thursday forenoon the later developments in marine engineering should be under consideration, with reference particularly to internal-combustion engines. Engineer-Commander C. J. Hawkes, R.N. (ret.), the new professor of engineering at the Armstrong College, is to deal with "Some Experimental Work in connection with Diesel Engines," and in view of the research he made, throughout practically the whole course of the war, when on the staff of the Engineer-in-Chief of the Navy, the paper should give rise to considerable discussion. Mr. William Denny, of Dumbarton, will read a second paper, on "Comparative Trials of 'Sti l' and 'Sulzer' Engines under Actual Working Conditions on Board Ship," and, as his firm have done experimental work on both these types of experimental engines, the contribution should be of very considerable interest. In the afternoon the members of the Institution will visit the Mersey docks and harbour, and will subsequently attend a reception by Sir Alfred Booth (the chairman of the Cunard Line) on board the Aquitania. Three alternative visits are put down for Friday—namely, to the Barrow-in-Furness works of Messrs. Vickers, Limited; the locomotive works, at Crewe, of the London and North-Western Railway; and the locomotive works, at Horwich, of the Lancashire and Yorkshire Railway. The programme, it will be recognised, is varied, and should stimulate thought and action.

MACHINERY FOR ROAD MAKING.

On Saturday last, the 22nd inst., the Institution of Municipal and County Engineers held an Eastern District meeting at Norwich, when opportunity was afforded of inspecting in service several interesting methods of road-making adopted by Mr. A. E. Collins, the City Engineer. In view of the increasing cost of labour Mr. Collins has found it an advantage to adopt a progressive attitude towards machinery, &c. For instance at the gravel pits worked by the corporation the gravel is washed and graded and stored in hoppers, whence it can be drawn off by steam carts standing in a depressed roadway. At another loading point the gravel is run by tramway over bins. From these carts, standing below, can be loaded very expeditiously. A Jeffrey wagon loader has also been put into service and will load a cart at the rate of about 1 ton per minute. This loader takes the form of a ladder conveyor driven by a single cylinder horizontal petrol engine. The machine advances into the heap as loading proceeds. A certain amount of manœuvring of the cart or wagon to be loaded has to be done, but this may be reduced to a considerable extent by having a man on board trimming. This machine can be attended to by one or two men on the ground in addition to the wagon crew of two. An interesting installation was shown at work in connection with trenching along roads, &c. This consists of an overhead rope-way carried by two frames on trucks which move along rails as the work proceeds. The carrier is arranged for two buckets.

The hoisting ropes and the traversing rope are wound on separate drums of the same diameter. These drums can be worked independently or locked and worked together, for hoisting or traversing. Four buckets are employed, two being filled in the trench, while two are being handled on the ropeway. The installation requires one man at the engine and one to handle the buckets, in addition to the men in the trench. A demonstration was given also of a petrol-driven trench tamper. This machine is by Messrs. Pawling and Harnischfegen and Co., Milwaukee, Wis., U.S.A., and has been described in ENGINEERING. In connection with tar spraying an insulated tar tank wagon was shown at work. This wagon is protected with about 4 in. of boiler lagging. The tar is loaded at a temperature of between 350 deg. F. and 400° F. at the works and keeps hot so long in these insulated tanks that it can be transported to the roads and used without further heating. A weighted broom follows the spray and assists in distributing the tar, but occasional patches have to be worked over by hand brush as well. Generally speaking it was an interesting demonstration of methods introduced by a mechanically-minded engineer to meet present labour difficulties. It must, however, be realised that small authorities cannot all indulge in machines to the extent possible with a larger authority such as Norwich.

PLANT GROWTH AND THE CRESCOGRAPH.

Though the engineer does not interfere in physiological controversies, the problems of plant life and growth interest us all, and an instrument like the Bose crescograph which is to give correct records, magnified up to 10,000,000 times, of life activity and of changes in length, may be put to use by physicists and engineers as well as by physiologists. Nobody doubts that the boundary line between plants and animals is indistinct; that both are sensitive and capable of movements; that both may or may not be individuals or collective beings, and that the discrimination of the individual may be very difficult. Professor Sir Jagadis Chunder Bose, of Calcutta University (which he has endowed), who was recently elected a Fellow of the Royal Society, has devised instruments by means of which he can make the plant trace its own life record. He finds that light and warmth stimulate and accelerate growth; cold and darkness retard it; the plant, most alive in the afternoon, does not really fall asleep before 6 a.m. to wake up in starts; the response of plants to a stimulus (in general a contraction) is no more instantaneous than in ourselves and takes about 0·05 second; poisons—alcohol, chloroform, sulphuretted hydrogen—act as stimulants in small doses and kill in strong doses; cut-off leaves die in 12 hours, whilst a rose bud has to be soaked in potassium cyanide for 4 hours before it is killed. Bose's first instrument was a lever provided with a long pointer writing on smoked glass; to reduce the friction he made the pointer vibrate electrically like a tuning fork and regulated the vibrations by a magnetic field, the pointer tapping the glass underneath it at regular intervals. By combining two levers he raised the magnification to $100 \times 100 = 10{,}000$; these levers were kept steady, the glass oscillating to and fro. In his latest crescograph there is only one lever, viz., a fine magnetised needle, in front of which another small magnetic needle bearing a mirror is suspended; the primary deflections of the long needle are further magnified in the secondary oscillations of the mirror and of the light spot. Such instruments may, of course, be extraordinarily sensitive. But Professor Bose did not, in the long discourse he delivered last Monday at University College, explain the mode of connection between the instrument and the specimen. In his first experiments he had made use of sensitive plants (*mimosa pudica*), and his diagrams showed the drooping branch attached to the end of his lever by a thread. In his demonstration of the latest crescograph the plant to be chloroformed (in its cylindrical container) was fitted with a wire clamp and connected by a stiff, hooked wire to the end of the lever. Professor Bose did not say how this is done, nor how he balances the wire weight and prevents injury to the plant by the clamping and interference with the circulation, &c. One understands that he can accurately measure the expansion of a stiff wire, caused by the approach of the warm hand, or the contraction of a moistened fiddle string, but we should like to know how the connections could be made to measure the expansion of a delicate plant. However, Professor Bayliss, Donnan, Lord Rayleigh and others have declared themselves convinced by a private demonstration that the crescograph correctly records growth and does not merely magnify accidental electrical or thermal disturbances. The fiddle-string demonstration, on the other hand, was made because Professor A. D. Waller—who had not been admitted to the private demonstration mentioned—showed last week, at the Royal Society, that a fiddle string behaved very much like a plant, and placed his apparatus at the disposal of others to experiment with—which Professor Bose declined to do.

LITERATURE.

Sewage Disposal. By LEONARD P. KINNICUTT, Professor of Sanitary Chemistry, Worcester Polytechnic Institute; C. E. A. WINSLOW, Professor of Public Health, Yale; and R. WINTHROP PRATT, Consulting Engineer. Second Edition, re-written. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* 6*d.* net.]

OWING to the progress that has been made in sewage treatment in the last few years and the better recognition of the many problems connected with it, the second edition of this well-known work has been submitted to a thorough revision, and to considerable extension. Generally, projects connected with sewerage have failed to attract the attention they deserve. When a notable scheme for the provision of a water supply to a large city is on foot, much interest is exhibited in the engineering problems involved and the manner in which they are handled. A sewerage scheme creates no such interest, and the engineer meets with little sympathy in his unsavoury task. But to get rid of the water supply of a town after it has been used, and that is the object of every sewage project, is a heavier task than to convey the fresh water in the first instance. Its volume is augmented by the town rainfall, and the solid matter increased by the detritus from the streets, it is polluted with all kinds of abomination, it carries the refuse of various industries, and besides the mineral and organic matter in suspension, great quantities of bacteria and protozoa, many possessing pathogenic qualities, have to be safely and expeditiously removed. It is not too much to say, that the sewage engineer of the last half century, following stereotyped rules handed down from a less sophisticated age, proved unequal to the burden laid upon him. The work of the chemist and of the biologist has had to be invoked in order to cope with the aggravated condition. The need of continued insistance on the employment of improved methods justifies the appearance of such a book as this, which urges the adoption of adequate methods in the interests of public health and sanitation, supporting its contention by many instances drawn from modern practice.

With the growth of population, further extension with consequent complications must be anticipated. The demands for the application of sewage systems are urgently pressed. Writing for Americans and utilising the statistics available in that country, the authors point out that of a total of 91,000,000 living in the United States in 1910, less than 35,000,000, or only 38 per cent., lived in communities provided with any sewerage system at all, and of these only 4 per cent. lived in communities provided with sewage treatment, the remaining 31,000,000 discharging their sewage untreated into the nearest body of water. Looking forward a few years, it is difficult to appreciate what the addition of the amount of impurity to the water system of the country portends. The self-purification of a stream is strictly limited. There is evidence to show that a stream will purify one-fiftieth of its volume of sewage, but not one-twentieth. Water carriage therefore becomes unsafe, though hitherto it has been regarded as an ideal method of sewerage for the individual, who rids himself of an incubus without trouble or danger, overlooking the disagreeable fact, that the problem of ultimate disposal is merely shifted to the community. The real problem of sewage disposal that has to be faced is the removal of the entire waste in such a way that it shall not be offensive or dangerous to the public in general. Subsidiary problems may arise, such as the recovery of any value the sewage deposit may have. The alleged value possessed by sewage sludge has long been a lure to the engineer and the hope of municipal officers, but though the manurial properties may in some instances have an economical importance, these have as a rule been over-estimated, and in the future are likely to be of even less consideration, for the activities of the chemist in producing cheap fixed nitrogen will influence detrimentally the engineering and commercial aspects of the sludge problem.

The authors lay down the important proposition that sewage treatment should not be carried further than to prevent local nuisance, and the removal of conditions offensive to sight and smell. To proceed beyond this point is uneconomical and extravagant, though health authorities, sometimes ambitious in their schemes and hypercritical in their tests, would like to purify the sewage till it resembles spring water. The bacterial purification might indeed be carried on till the effluent was as pure as many public water supplies, but such fastidious tastes should not be encouraged, and therefore the authors, while alive to the necessity of supplying adequate treatment and safe removal, add the words "at a minimum cost." This suggests a very practical treatment, and throughout the authors never disappoint the reader in that respect.

The description of the schemes in use for the disposal of sewage naturally starts from the primitive form of dilution, in which the offensive material is discharged into a stream or tidal waters by properly-located outlets. With care and under suitable conditions the process is one of the most economical, satisfactory and efficient methods of sewage disposal, for with sufficient dilution such a discharge constitutes a sound method of purification. Its success depends in a great measure on the prompt and intimate mixing of the sewage with the diluting water and its contained oxygen. Its failure depends generally upon an increase of population without a corresponding increase in the quantity of running water. The Chicago Drainage Canal illustrates these conditions very pertinently. In this case, the quantity of discharged sewage was so great that the ratio of the sewage to water was as 1 : 10. The result was disastrous. At New Orleans, on the other hand, the vast volume of the Mississippi absorbs and purifies the polluting material with ease. The British Royal Commission on Drainage recommend a dilution of 500 volumes for crude sewage, 300 volumes for settled sewage, and 150 volumes for chemically-precipitated sewages.

With the scheme of dilution came to be connected a system of straining, designed to hold back the coarse particles in suspension, and in some form this has been retained as an essential step in most processes of sewage treatment. Herein is seen the beginning of sedimentation tanks, which originally constructed to remove the grosser and heavier mineral particles, as road sweepings, have been improved and adapted to retain a large portion of the suspended organic material. It is easy to pass from these early schemes to the more recent process, in which tanks were utilised for chemical precipitation, and for a while dangled before the public the hope of a latent source of unexpected wealth. The hope was not realised. Wealth to be available must be concentrated, and each gallon of sludge contained so little of value that it never reimbursed the expense of collection. Some very material advantages can, however, be claimed for chemical precipitation, more particularly in the case of sewage highly charged with industrial waste, but it is doubtful whether in the most favourable case, the cost is justified. Septic tanks are a further development in the sense that they came later in time, and in many cases displaced the process of sedimentation and chemical precipitation, but the septic tank is simply the cesspool of our forefathers, regulated and controlled. These have had a somewhat chequered career, and have been alike praised and blamed too much. Their rival has been the Imhoff tank, which may be better suited for large communities, but for simple installations, the one-story septic tank of

Cameron has marked a distinct advance over plain sedimentation, as regards digestion and liquefaction of sludge, and is likely to retain a distinct field of usefulness.

Long and costly lawsuits have decided that Cameron was the first to subject the flowing current of sewage to the action of anaerobes and aerobes, under conditions which secured their separate and successive action, but developments came on rapidly and rivals occupied the ground he had successfully prepared. The hydrolytic process developed by Travis, the Imhoff tank combining the advantages of all its predecessors, the Dibdin plate bed, possessing some novel features, and the contact bed, are all the product of the same master thought, though, as the authors point out, the septic and hydrolytic tank are primarily anaerobic in their action, the others are rendered effective by aerobic bacteria.

The construction of these forms of tanks, the points of difference and the merits of each, are very fully described, the details of particular installations being given very clearly, but it is impossible to summarise the results in a brief space. As instancing the uncertainties of popular favour, and of the nice balancing of the defects and merits of rival schemes, it may be recorded that while the Travis' form of separation was never adopted in America and the Imhoff tank attained wide popularity, a decided reaction has recently manifested itself against the latter, and a suspicion is gaining ground that it has been praised beyond its deserts, and that in particular the dissemination of noxious odours is a very objectionable feature.

As an alternative to the use of tanks, the distribution of sewage on the land, or sewage farming, offers some favourable points. Under suitable conditions the soil is capable of absorbing the liquid and digesting the solid constituents of the sewage. The operation may be economically and even profitably conducted. The elements of success require the command of considerable areas of cheap and infertile sandy soil with light rainfall. The price of land, the cost of labour, the available markets, the capable management of the farms, are all uncertain factors which have to be risked, and may easily turn an expected profit into an actual loss. The danger of sanitary efficiency, the real object to be considered, being sacrificed to economic success must not be overlooked.

The process of purification that followed from the distribution of sewage over waste land was originally no more clearly understood than was the primitive method of dilution by water. The fundamental process at work is the oxidation of organic matter by means of bacterial life, but this fact was not recognised, and therefore not utilised till the last quarter of the past century. Sir E. Frankland was among the first to perceive the chemical oxidation of organic matter to water, carbon dioxide and nitrates, and to insist upon the necessity for intermittency in operation. But the importance of intermittent filtration was not appreciated at the time, and the biological purification of sewage made little headway in this country. America, more alert, experimented wisely and well, demonstrating that not only must the sewage be applied intermittently, but also in small doses, in order that the air supply necessary for its oxidation may be available. Once the sanitary engineers were possessed of this thought through experience, improvement was rapid along the lines indicated. The contact bed where aerobic and anaerobic conditions follow alternately; the trickling filter in which the sewage is distributed continuously in a fine spray over the surface of the bed; and the latest development of the activated sludge process are all modified and improved devices for applying the principles that Frankland enunciated and American perseverance has utilised. The chemistry and bacteriology of intermittent filtration like the physics and chemistry of the contact bed will repay careful study, for the authors have availed themselves of the latest information, and the description of the systems in which these principles are operative is full of interest.

The latest method of sewage disposal and in some respects the most successful, is that known as the activated sludge process, or the forced aeration of sewage, mixed with a certain volume of previously aerated or activated sludge. Dr. Fowler, of Manchester, may claim credit for its introduction, for the authors pay him the graceful compliment of admitting that it was "the Manchester studies and particularly the discovery of the effectiveness of previously aerated or 'activated' sludge in promoting oxidation, which really gave us this important method of sewage purification." The advance in biological chemistry has been an essential factor in the development of the process, and to be applied successfully the engineer must adapt his plant and conduct his operations according to the conditions determined by the bacteriologist. In 1913, Fowler was able to demonstrate that the inoculation of sewage by oxidising bacteria materially shortened the time for clarification. Later experiment has fully proved that a mixture of one volume of activated sludge with four volumes of sewage, when aerated from 4 hours to 6 hours, with 15 cub. ft. of compressed air per square foot of floor space, gave an effluent after sedimentation, well clarified and non-putrescible. When air alone was applied, five weeks of aeration were required to effect complete nitrification. At present, the process may recommend itself by reason of its novelty, but it undoubtedly fills an important place in sewage management, and probably indicates the direction which future development will follow. The authors, however, think it necessary to warn those who propose trying it, that it is by no means a panacea, and in all cases it should not supersede the treatment on trickling beds. The principal advantages consist in the high degree of purity attained in the effluent, the small area of land required—10,000,000 gallons can be treated per acre per day—and the freedom from local nuisance. On the other side of the ledger appear the high power cost, the difficulties which may be expected from trade wastes, and the irregularity of flow with so delicately adjusted a biological process. Further, a very great amount of wet sludge has to be handled, amounting to 15 cub. yards to 30 cub. yards per 1,000,000 gallons of sewage. In any case, the disposal of sewage sludge is a large question, and when the recovery of trade wastes is attempted, or it is proposed to utilise any portion as manure, the operations become complicated and can be costly. The problem is quite adequately treated by the authors, and though we cannot enter into any details we may quote the following warning: "It is strange to note how often a plant is carefully and intelligently planned to separate the solid from the liquid constituents of the sewage and to purify the latter, while the sludge is left to be disposed of by some spontaneous happy thought when the occasion shall arise."

After the study of many schemes in which the authors display their accumulated experience by the clearness of detail and the points selected for minute description, one fails to understand why so many should be in operation and none has shown marked superiority over its rivals—to use the authors phrase "Why there is no 'system' of sewage disposal." Perhaps the answer is to be found in the remark of an English sanitarian, "I have so repeatedly seen excellent works give bad results on account of inefficient arrangement, and very defective works fair results on account of the efficiency of the manager, that I have come to regard the manager as being even more important than the works." With such a *vade mecum* as the authors have provided, the work of management should be easier and performed with greater intelligence.

Oil Engines; Details and Operation. By LACY H. MORRISON. New York: McGraw-Hill Publishing Company, Inc.; London: Hill Publishing Company. [Price 30s. net.]

THIS latest book on oil engines, published this year, to come into our hands is American in every sense, and deals exclusively with American engines. The engineering products of every country bear a relation to the characteristics of the race, but since engineering is a science and can hardly be described as temperamental, the reflection of characteristics is on that account not sharply defined. It is, nevertheless, an interesting study to examine the methods of designers in other countries in attacking and solving the same problems as we are confronted with. Before our perusal of this volume we, frankly—in spite of the abundance of fuel oil in the United States of America—had not formed the opinion that America had attacked the problem of the oil engine so fully as is evidently the case, nor did we think that it had products of its own in this new branch of engineering which bore so individualistic a stamp. With only one or two exceptions the designs illustrated are home products, and the results of the operation of European licenses are quite clearly seen in the two exceptions to this general rule. It might here be remarked that in many ways American practice in oil engines is not to be admired, and recently almost all high-powered Diesel engines built and building in America have been constructed under licence from well-known European firms of considerable experience.

This book deals generally with the smaller type of oil engines of all types, Diesel, semi-Diesel, or hot bulb and high and low compression, in most cases as applied to land practice. Wherein, with such engines, is American practice distinct from British or European? Whilst it may be contended that the Continental designer is content with a solution that accurately follows known theory, is pleasing to the eye, and combines features so artistic that they sometimes impose difficulties for the foundryman and machinist to solve, and whereas with British engineers, practical considerations predominate at times in contradiction to postulated theory and a direct method of attack is the only one considered, yet both are probably to be preferred to the American standard that seems to be gauche, although practical in that very crude mechanisms are introduced to rectify the effects of indifferent design and lack of highly skilled workmanship. We are somewhat surprised at the want of appreciation of the temperature conditions to be carefully legislated for in internal-combustion engines if success, especially with large units is to be won, but this fact probably explains the evident desire on the part of American constructors to depart from the standard Diesel cycle, and seek a less exacting solution in the various alternative types such as the hot bulb, high and low compression oil engines, or by building under licence. The American designs for the castings such as cylinders, liners, cylinder heads and pistons present few problems to the foundry and machine shop, but evince little effort to cope with the actual temperature conditions imposed when running under full load. A large number of the American land oil engines are of the horizontal type following on the established practice for small gas engines. Such engines are relatively simple and cheap units, and possess the advantage of requiring very much less head room than the standard vertical type. Another distinct characteristic is the quite frequent adoption by American designers of the open type of cylinder fuel injection valve first adopted by Körting in Germany. With this valve a measured quantity of fuel is delivered during the compression stroke of the engine to a receptacle at the lower or inner end of the fuel injection valve actually in the combustion chamber, and the timed opening of the needle valve admits the injection air to pick up this charge of fuel and traject it into the combustion chamber. Such a type of valve with slight modification is successfully used also for tar oil.

This somewhat simplified fuel valve where the usual gland has only to be packed against the air pressure, where the fuel does not require to be delivered by the fuel injection pump against the pressure of the fuel injection air, has not been adopted in Britain. It undoubtedly effects certain improvements and is strongly recommended as worthy of the closest study.

We do not note in this review of American Diesel engineering any other principal factors that can be said to show the way to British exponents of the internal-combustion engine. It may well be, however, that from a close study of the detailed construction there will be manifest certain directions in which workmanship can be avoided and an equally successful issue achieved.

So much for the subject of the book under review. The treatment is briefly to describe with little criticism the principles and the leading characteristic of the engines and to pass on to a full consideration

of running adjustments and factors that make for successful operation.

With this last sphere the author is quite familiar and the chief pleasure in reviewing this volume is the appreciation that the writer is detailing considerable personal experience. As an instance we have not seen reproduced better cylinder indicator diagrams than those here given to illustrate defective valve setting and other minor faults of adjustment. When expanding the theoretical considerations underlying such defects and remedies, or in treating of matter concerning other than relatively small American four-stroke cycle engines, this text book is not so accurate.

The work is comprehensive and full with a good index, there are 457 pages, 357 illustrations, such as drawings, photographs and diagrams and a number of tables. The volume is well printed, with good sized type and of suitable paper.

Scientific Method. Its Philosophy and its Practice. By F. W. WESTAWAY. London: Blackie and Son, Limited. [Price 10*s.* 6*d.* net, bound.]

THE great man of science is not necessarily a good teacher, nor does he necessarily follow any definite method throughout his researches and his teaching, Speaking generally, the non-brilliant, cautious, possibly slightly pedantical worker, succeeds perhaps better in helping the student to grasp the principles of his science than the brilliant, original scientist, who attracts and inspires multitudes of students, but who really teaches not more than the very few who are able to follow his ingenious lectures. Even the sound teacher to whom the average student is most indebted might be puzzled to label his method. Mr. Westaway does not write by any means only for the science teacher; yet he may enable the teacher to decide which master he has been following and which he ought to follow. But as Mr. Westaway does not wish to impose his own views upon the reader, rather desiring to interest the reader sufficiently for further studying the authorities cited, the reader may simply peruse the volume at his leisure, grateful for the fruitful suggestions received and willing to examine. He will not always agree probably, but he will be glad to open the book again and again.

We will briefly outline the contents of the volume to mark the author's method. Book I, the Philosophy of Scientific Method, deals with Humanism *versus* Realism, Words and their Elusiveness, Plato, Aristotle, Scholasticism, Bacon, Descartes, Locke and Hume. Book II, the Logic of Scientific Method, is devoted to the methodologists, Whewell, Mill, John Herschel, Bain, Jevons (whom Mr. Westaway quotes most frequently), Welton, A. Sidgwick—to Induction, the Principles of Investigation, Analysis, Generalisation, Hypotheses, Analogy, Probability, Measurement, Error and Correction. Book III, exemplifies the work of some famous men by quotations from their books, Wallace, Darwin, John Lubbock, Harvey, Newton, Faraday, &c., not in any historical order, we notice, and refers very briefly to some other scientists. Book IV, finally, on Scientific Method in the Class Room, describes the Heuristic Method and Laboratory Instruction, after Ganong, A. Smith, H. E. Armstrong, J. B. Russell and others, quotes from Pupils' Notebooks, and gives examples of solving mathematical problems. The Appendix is entitled Retrospect and Reflections (1912 to 1918); it opens with the words written in 1912 (the year of the publication of the volume) "When it looked as if the nations were heading to destruction."

It will be seen that Mr. Westaway cannot be charged with taking a narrow view of his subject. In this second edition the specific claims of philosophy are indeed more strongly urged than in the first edition of his work. But Mr. Westaway seems a little fond of generalisation, in words rather than in deeds. We read in the preface: "On the one side we have Germany, clear-headed and thorough; America, original and enterprising; Japan self-denying and observant; France, painstaking and clever; all four nations believers in *work*. On the other side we have Britain, insular and unsystematic, looking upon work as a nuisance because interfering with pleasure." We find in the book more of such sweeping characterisations—which, we acknowledge, still enjoy favour. We consequently expect a fairly international treatment of a subject like scientific method. But apart from the classical philosophers Mr. Westaway's authorities are practically all English. A chapter is devoted to Descartes; Franklin and Guy Lussac are given an opportunity of exemplifying their methods of research; otherwise foreign philosophy and science are noticed by mere references. Mr. Westaway might have been less exclusive, we think, and we do not agree, *e.g.*, with his comment on the following experiments of Humphry Davy: common salt being found in the air during the early electrolytic work, it was suspected that electricity had the power of generating acids and alkalis; Davy reduced the alkali more and more by working with distilled water in vessels of agate or gold and in a vacuum, and by avoiding all contact with his fingers. "He thus detected a previously unsuspected antecedent," is the comment.

We may add one final remark. We do not wish to talk relatively, nor to blame Mr. Westaway for keeping relativity out of his section on Measurement. But we should hardly conclude a book on scientific method with the words: "Let each youth be taught to give the whole energy of his soul to the discovery of the exact fact, the exact law, the exact principle that underlie any and every problem which life may call upon him to solve." A word of caution and tolerance should have been added. Are we certain of any exact facts, laws or principles?

BOOKS RECEIVED.

United States Public Document No. 34. *Third Annual Report of the State Department of Health of Massachusetts, for* 1917. Boston: Wright and Potter Printing Company, 32 Derne-street.

Johnson's Materials of Construction. Rewritten by M. O. WITHEY and JAMES ASTON. Edited by F. E. TURNEAURE. Fifth edition. New York: John Wiley and Sons, Inc. London: Chapman and Hall, Limited. [Price 30*s.* net.]

Graphical and Mechanical Computation. By JOSEPH LIPKA, Ph.D. New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Limited. [Price 18*s.* 6*d.* net.]

Whittaker's Electrical Engineer's Pocket Book. Edited by R. E. NEALE, B.Sc., A.C.G.I. Fourth Edition. London: Sir Isaac Pitman and Sons, Limited. [Price 10*s.* 6*d.* net.]

The Patents, Designs and Trade Marks Acts, with Notes on all Recent Decisions and Changes in Law and Practice. By H. FLETCHER MOULTON and J. H. EVANS-JACKSON. London: Butterworth and Co. [Price 17*s.* 6*d.* net.]

Guide Pratique pour le Calcul des Lignes Electriques Aériennes, et Méthods Graphique pour le Calcul des Pylones Metalliques. By J. PIOUCHOU, TH. HEILMAN and R. VALENSI. Grenoble: Jules Rey. [Price 6 francs.]

Five Figure Logarithms and Trigonometrical Functions. Edited by W. ERSKINE DOMMETT, A.F.Ae.S., M.I.Mar.E., A.M.I.A.E., and H. C. HIRD, A.F.Ae.S. London: James Selwyn and Co., Limited. [Price 1*s.* 6*d.* net.]

The Use of Low-Grade and Waste Fuels for Power Generation. By JOHN B. C. KERSHAW, F.I.C. London: Constable and Co., Limited. [Price 17*s.* net.]

Perils of the Sea. How we Kept the Flag Flying. A Short History of a Long Fight. Compiled by L. GRAHAM and H. HORTON-SMITH, M.A., F.S.A. London: Imperial Maritime League. [Price 5*s.* net.]

The Indicator Handbook: A Practical Manual for Engineers. By CHARLES N. PICKWORTH. Complete Edition. Manchester and London: Emmott and Co., Limited. [Price 7*s.* 6*d.* net.]

America's Merchant Marine, a Presentation of its History and Development to Date, with Chapters on Related Subjects. New York: Bankers Trust Company.

PERSONAL.—Mr. Frank Hoyle Brunt, Assoc.M.Inst.C.E. states that he has resigned his position as waterworks engineer to the Rochdale Corporation in order to undertake private practice as a civil engineer, and, after the 31st inst., his address will be 100, Victoria-street, Westminster, S.W. 1. (Telephone, Victoria 1100.)—An amalgamation of interests has been arranged between the Lancashire Dynamo and Motor Company, Limited, of Manchester, and the Crypto Electrical Company, Limited, of Willesden.—Messrs. Buck and Hickman, Limited, state that their Birmingham warehouse and offices have been transferred from 55, Station-street, to 23, Newton-street, Corporation-street, Birmingham.—Mr. R. S. Johnson, for many years connected with the firm of Messrs. Workman, Clark and Co., has joined the Board of Messrs. Cammell Laird and Co., and will assist Sir G. J. Carter at the Birkenhead Works.—Messrs. the General Electric Company, Limited, state that on and after 31st inst. the telephone number of the West-End depot (5, Arthur-street, New Oxford-street, W.C. 2) of Pope's Electric Lamp Company, Limited, will be changed to Gerrard 6074 (2 lines).

THE MANCHESTER ASSOCIATION OF ENGINEERS.

A VISIT of considerable technical interest was made by the Manchester Association of Engineers on the 19th inst., when they inspected the engine works of Messrs. Galloways, Limited, at Knott Mill, Manchester. The attendance was something like 150, and the meeting was in every way successful. The whole of the works were thrown open for inspection, and much machining work of a heavy type was to be seen in progress. For most visitors, however, the main interest probably centered in the large uniflow engine and the 1,850 h.p. gas engine, both of which were nearing completion in the works. Other products of interest were a three-crank reversing rolling mill engine, the erection of which was, however, in a somewhat early stage, and a hydraulically-operated drop-valve mechanism.

The uniflow engine which is being built for Messrs. Lysaght, Limited, is stated by the makers to be probably the largest of its type in the world. It has a single cylinder 60 in. diameter and 72 in. stroke. It is intended for driving a sheet mill, and will run at 28 r.p.m. and give 1,500 h.p. The engine is, however, capable of developing double this power at a higher speed. Some interesting features were incorporated in the construction, particularly in connection with the building-up of the cylinders and the form of the piston. The two main portions of the cylinders are separate castings, as is the exhaust belt. This latter is, of course, relatively weak, owing to the presence of the exhaust ports, but the whole arrangement is reinforced in a very neat way by carrying a ring of bolts right through the exhaust belt and so solidly joining the two cylinders. The piston is built up of two end castings drawn hard up against collars on the rod, and is made without any central barrel joining these ends. At the lower side, however, the space between the end castings is filled with an articulated arrangement consisting of a series of slippers which can move relatively one to the other. These take the weight of the piston and distribute the wear on the cylinder. The piston rings are carried by the end castings.

The gas engine which was on view was one of five being built for the Barrow Haematite Steel Company, and will be driven by blast furnace gas. Messrs. Galloways have now been building large gas engines of this class for a number of years. The engine has two cylinders in tandem, each 45 in. diameter by 51-in. stroke. The four-stroke cycle is used, the speed is 94 r.p.m. and the output 1,850 h.p. Governing is through a servo-motor operated by a comparatively small centrifugal governor. Another interesting piece of machinery on view was an hydraulically operated drop valve intended for use on uniflow and other engines. The arrangement incorporated a closed oil circuit containing a small cylinder and piston which was arranged to be operated by the valve gear of the engine. The pressure generated by the movement of this piston was transmitted by the oil to a diaphragm, which opened the main valve against the pressure of a spring. When the pressure was released the spring at once closed the valve. The gear appeared to be very sensitive and rapid in its action. The valve lift was varied by varying the stroke of the piston.

THE SURVEYORS' INSTITUTION.—We are informed that the country meeting of this Institution is to be held in Gloucester, on July 8 and 9, when papers will be read and discussed, and visits paid to places of interest. Further information can be obtained from the secretary, 12, Great George-street, Westminster, S.W. 1.

SOCIETE DES INGENIEURS CIVILS DE FRANCE.—The Société des Ingénieurs Civils de France, of which a British section was formed and inaugurated in November last (see ENGINEERING, vol. cviii, page 726), is now organising for the end of June a short visit to Paris and to the mines and factories of the devastated regions in the North of France. In order to make this visit as comprehensive as possible, it has been decided not to confine participation only to members of the British section of the société, but to admit all members of recognised engineering institutions in the United Kingdom. The provisional programme states that the official time-table covers the period from Tuesday evening, June 22, to Friday night, June 25. It is, of course, left open to members either to proceed to Paris on their own account, meeting the party there or, should they care to, to extend their visit beyond the date mentioned. The cost, to members, of the official part of the tour will be approximately 600 francs per head (about 12*l.*); first-class return railway fare, London to Paris, 6*l.*; expenses in Paris about 1*l.* per day. Arrangements as to hotel accommodation in Paris will possibly be carried out by the parent society. Members are reminded that passports are still necessary for France, but that they need only be taken for Paris, as there is no difficulty, once there, in proceeding to other parts of France. Ladies will be welcome on this occasion. Fuller details will be given on application to the Honorary Secretary, 45, Great Marlborough-street, London, W. 1.

WELDED STEEL SPECIALS AS A SUBSTITUTE FOR CASTINGS.

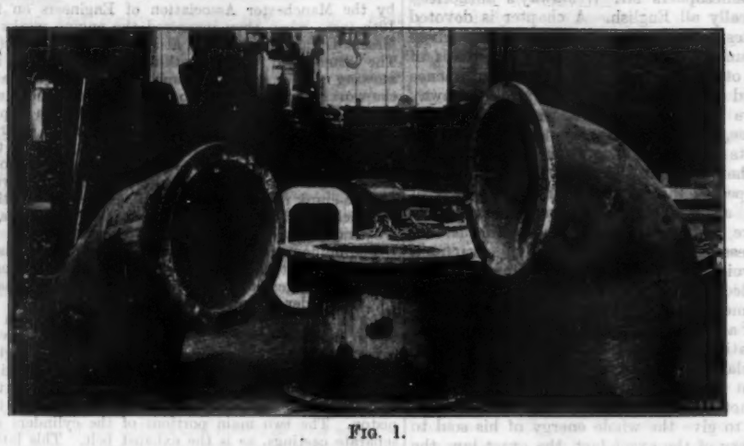
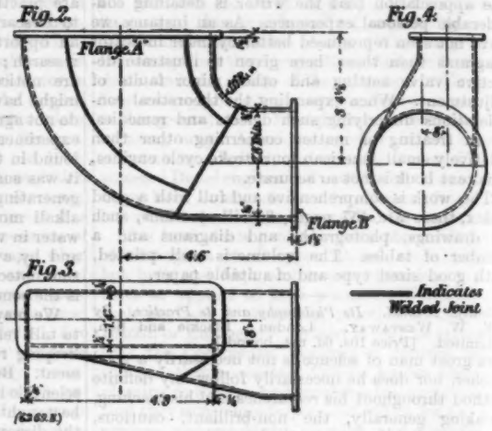


FIG. 1.



During the recent prolonged strike of ironmoulders throughout the country, engineering firms were compelled to resort to many devices in order to mitigate the worst consequences of the shortage of castings and to reduce as far as possible the unemployment of workmen in other trades. Some of the lessons taught by necessity may have beneficial results in the future, and the impetus given to the adoption of machine moulding and to the use of drop-forgings will tend to the advancement of engineering practice. The Fraser and Chalmers Engineering Works of the General Electric Company at Erith found themselves, during the period of the strike, sorely in need of some special pipe castings of large size, without which certain very important work would have been brought to a standstill. Castings being impossible to obtain, it was decided to see what could be done by way of a substitute, in building up pipes of the required shape from steel plates by welding together suitably-formed pieces. Forged steel flanges were afterwards welded on, and the final results realised all the hopes of the originators of the method.

The photograph reproduced in Fig. 1, above, shows three specials manufactured by the method indicated, two of the pieces being right-angled bends and the third a straight taper length. All are constructed of $\frac{1}{4}$ in. steel plate and have $1\frac{1}{2}$ in. forged steel flanges welded on. The plates are joined by V-welding inside and out. The two bends shown in the photograph are of 32-in. diameter, the radius of one being 27 in., and of the other 32 in. The left-hand bend is composed of three sections of plate, while the longer one on the right is made of four sections. Additional longitudinal welds can be seen in the sections carrying the upper flanges. These occur for constructional reasons, the plates being cut and rewelded at these points for the purpose of fitting the flanges. The short pipe shown in the photograph standing between the bends is 33 in. long, tapering from 27$\frac{3}{8}$ in. diameter at one end to 32 in. diameter at the other.

One of the most striking examples, however, of the method of manufacture was a special piece which unfortunately had to be put into service before a photograph could be obtained, but the line drawing, Fig. 2, shows the complicated shape that was successfully built up. The actual pipe might easily have been mistaken for a casting on casual inspection, so smooth was its contour. The welded seams are indicated by lines on the drawing. The pipe is made of five separate plates, $\frac{1}{4}$ in. thick; the radius of the bend is 12 in., the rectangular flange is 57 in. by 16 in., and the circular flange is 32 in. diameter. This special pipe was required in connection with the testing of a large Fraser and Chalmers turbo-compressor, delivering 20,000 cub. ft. of free air per minute at a pressure of 100 lb. per square inch. It was direct coupled to a turbine also made by the company, developing 4,100 brake horse-power at 3,000 r.p.m.

The cost of the welded specials was not materially different from that of castings, but the labour and material entailed in the construction of patterns which might never be used again, was, of course, avoided. The previous experience of the Fraser and Chalmers Engineering Works in the manufacture of welded pipe work in connection with their large turbo-blower and gas-cleaning installations, no doubt stood them in good stead in the present instance, but the enterprise shown in dealing with the situation with which they were confronted is none the less to be commended.

THE BERWICK ELECTRIC RIVET HEATER.

We recently had occasion to refer to the fact that the heating of rivets by electrical means had made some progress in America, and we are now able to illustrate the machine which has been brought out by the American Car and Foundry Company of 165, Broadway, New York. Considerable experience has now been obtained with the working of this heater. The machine is of the resistance type and is of quite simple construction, as will be gathered from the figure below. It consists of a pressed steel frame carrying the transformer units at the top and fitted with pedals on the front side. During heating the rivets are held vertically clamped between two electrodes, as shown in the figure. The machine shown is arranged to hold

three rivets at a time, but other patterns are made ranging from a small machine designed for one rivet to a large one arranged to heat seven rivets at once.

The rivets to be heated are held between copper electrodes which are connected together at the back of the machine by a laminated copper conductor. The electrodes are welded to the conductor. These electrodes, together with their back connection and the rivet which is being heated, form a single closed coil which acts as the secondary of a transformer. The primary of the transformer consists of flat wound coils lying between the various secondary circuits. A laminated core is carried through the grouped coils, and asbestos shields are placed on each side of the secondaries to protect the primary coils from the heat which is produced. The lower electrode is connected to the pedal, and depression of this draws the electrode down and enables the rivet to be placed in position. The pedal is then released and the rivet is held secured, as shown in the figure, and at once heats up. The primary circuits are controlled by a switch at the left-hand side of the machine, but it is not necessary to break the primary circuit when a rivet is removed. If the machine is standing, or working intermittently, it is, of course, desirable to break this circuit to cut out the no-load losses.

The primary coils are arranged to operate from a 220-volt or 440-volt circuit of 60 to 25 periods. The secondary current is of the order 1,000 to 5,000 amperes, and the voltage about 2. This very low secondary voltage makes the machine very convenient in working, and it is unnecessary for the operator to wear gloves or use insulated tongs. The heating of a rivet takes from 20 seconds for the smaller sizes to 30 seconds for the larger. A single rivet can be heated on the machine, and it is not necessary that all the pairs of electrodes should be used at any one time; 20 kilowatt hours will heat 100 lb. of rivets regardless of size. The makers of the heater have used it in their own works over a period of five years, and state that the saving as compared with oil or coke heating varies from 20 per cent. to 70 per cent. These figures refer to energy, fuel and maintenance. There has been also a very large saving in the number of rivets wasted owing to burning and scaling. This figure for the average plant is placed at from 5 per cent. to 10 per cent. of the total used, and the loss is almost entirely eliminated by the electric heater. The rivets are heated by the current from inside so that there is no bad scaling and there is no stack of rivets under heat at one time as with an ordinary fire. Waste occurs with the usual arrangements owing to rivets remaining too long in the fire, or being left in at meal-times and the end of shifts.

"INDUSTRIAL ARTS INDEX."—This is the title of an index to engineering, trade and business periodicals which is issued by the W. H. Wilson Company, 958 to 964, University-avenue, New York City. It forms a very handy means of reference to all the articles published in the periodicals in question.

THE AUSTIN MOTOR WORKS.—Speaking at a special meeting recently held to celebrate the reorganisation of the Austin Motor Works for the mass production of cars, tractors and lorries, Sir Herbert Austin, the chairman of the company, pointed out that the Austin Company had already delivered some 2,000 cars, starting eighteen months ago; and but for the moulders' strike would have delivered 5,000 at the present date. They were, however, not alone in being somewhat behind their programme. He had received a private communication from a friend in the United States in which similar conditions were portrayed, one company alone being stated to be 350,000 cars down on their schedule. The Austin Motor Company's programme, while not comparable in actual bulk with such figures, was none the less a genuine instance of mass production. Twelve months ago, the programme of production was fixed at 150 cars, 60 tractors, 60 lorries, and 100 lighting sets per week. The first part of this programme had now been practically accomplished, as the firm was turning out 150 chassis a week, and over 120 bodies and 60 tractors. This was only a beginning. All further progress was, however, dependent upon the loyal co-operation and assistance of sub-contractors and the allied trades generally, and Sir Herbert put in a strong plea for a combined effort on the part of all the trades concerned either directly or indirectly with motor car production. If such a general quickening of supply throughout the country could be effected, the difficulties which related chiefly to the gathering in of the very large quantities of raw material and accessories required would disappear, and production figures would go up very rapidly.

STEEL WIRE AND WIREDRAWING.*

By E. A. ATKINS, A.M.I.Mech.E.

Modern Practice.—The introduction of mild steel or ingot iron has more or less changed the character of the wire-drawing trade; in wire-drawing, as in other industries, mild steel having almost pushed the use of wrought-iron out of existence. With the exception of a little Swedish charcoal iron, wrought-iron has almost ceased to be used in the making of wire. Generally, mild steel is purer and more uniform in its composition than ordinary wrought-iron, and consequently much heavier pieces can now be drawn than obtained in the older days. The raw product that comes into a wire works is the rolled rod from the steel mill, this for ordinary purposes being about 5 gauge, and for special purposes any other sizes and shapes as required. In the rolling-mill billets are reduced down to bars about 2 in. square with rounded corners, the latter then being rolled on until the required size of wire rod is produced.

Cleaning.—One of the most important processes in connection with the making of wire is the proper cleaning of rods, so as to free them entirely from any form of scale, as this latter is fatal to good wire-drawing. The general practice is to submerge the rods in cisterns of dilute hydrocholric acid until the whole of the scale has been completely "pickled" away. After cleaning in this form the rods are then well washed and allowed to stand until they are "browned" or coated with a film of ferric-hydrate. This "coating" of wire is exceedingly important and should be carried out with great care, as the subsequent drawing of the wire, especially for what is known as long holing or carrying the wire to fine gauges, depends very largely upon the proper coating of the wire. After coating, the rods are dipped into a vat of boiling lime water, lifted out, and well dried in hot ovens. The thin coating of lime on the top of the ferric-hydrate serves the double purpose of protecting the brown coat and also of keeping the rod surface from corroding.

Pointing of Rods and Wire.—Before either rods or wire can be passed through the draw-plate, it is necessary that the ends should be pointed in a conical form. This was originally done by hammering or filing, or a combination of both. The bulk of the pointing at the present time is done by the aid of either rotary swaging machines or grooved rollers, in some cases other special mechanical devices are used for forming the point.

Methods of Wire-drawing.—There are two general methods of wire-drawing in vogue, one known as the "dry," and the other as the "wet" method. In dry drawing the rod or wire is passed through a drawplate or die which has a tapered hole, the lubricant in this case being a special form of well-dried soap. In wet drawing the wire or rod is first coated with a thin film of copper, this latter being deposited by passing the rod or wire through a special solution containing sulphate of copper. The wire then passes through a soapy solution and on through the hole of the draw-plate. This method of wire-drawing a hard metal within a shell or skin of a softer metal has been in use for more than a century, and in practice gives very good results.

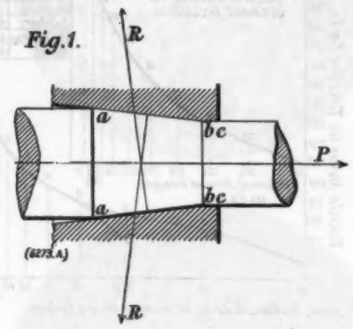
THE THEORY OF WIRE-DRAWING.

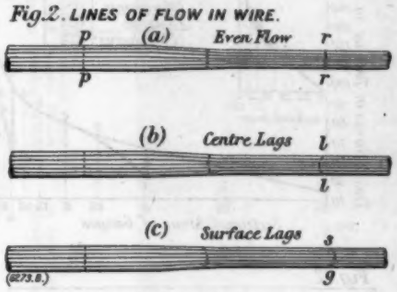
In theory all that happens to a piece of rod so as to convert it into wire is that its length is increased and its diameter reduced by stretching or elongating. It is possible to reduce the diameter of a soft wire by simply stretching it either by having one end fastened and pulling at the other, or by fastening both ends and pulling downwards. But whilst this method is carried out by a few native or artistic craftsmen in soft metals, for practical purposes the method is of no use for the making of steel wire. What really happens when the rod is passed through a draw-plate is that the wire is assisted to stretch at any one instant over a very short length. Thus, in Fig. 1 the complete reduction of the wire takes place over the length *a* to *b*, the hole between the points *b* and *c* being cylindrical. The problem, then, resolves itself into that of the flow of a metal through a reducing orifice.

In Fig. 1 a diagram is given showing the forces that act upon the wire in the operation of wire-drawing. The force *P* represents the pull on the wire, and the forces *R R* the resultants of the circumferential pressure. In the case under consideration it is assumed that a No. 5 gauge rod is being drawn down to No. 8 gauge wire, the pull *P* being 1,500 lb. The pressure on the shoulder of the wire works out to 63 tons per sq. in. of curved surface.

In considering the problem, a unit volume of material is taken, represented by the truncated cone *a a*, *b b*. The work done on this unit volume by compression equals 15 ft. lb. The work done by the force *P* in stretching equals 9·6 ft. lb.; so that the total work done in reducing the unit volume from No. 5 gauge rod to No. 8 gauge wire equals 24·6 ft. lb. The actual work done equals 35·9 ft. lb. So that the work lost in friction amounts to 11·2 ft. lb. This, therefore, compared with the actual work done, gives 31·3 per cent. of work which is used in overcoming friction.

With the enormous pressure of 63 tons per sq. in. on the shoulder of the hole, it is manifest that some form of solid or semi-solid lubricant must be used in wire-drawing.





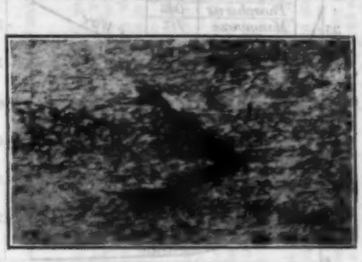


FIG. 3.

Micro-photo of core of fractured wire, to a magnification of 60 diameters, showing incipient cuppiness through a hard high carbon core. Carbon content of wire 0·60 per cent. Carbon in core 1·2 per cent.

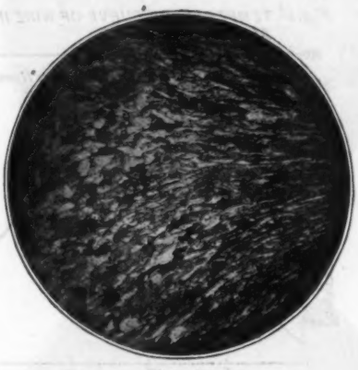


FIG. 4.

Microphotograph showing deformation of crystals during the "flow" of mild steel. Magnified 40 diameters.

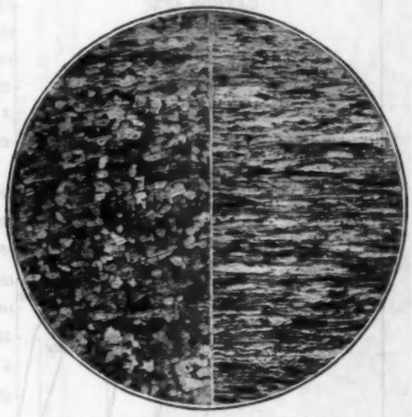
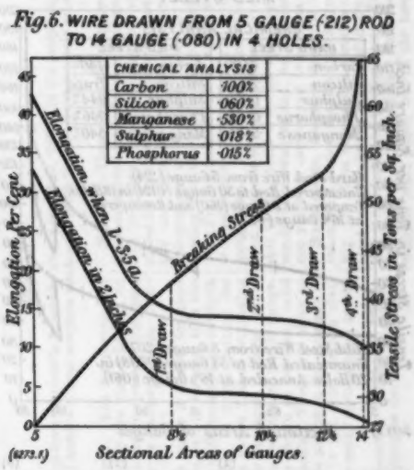
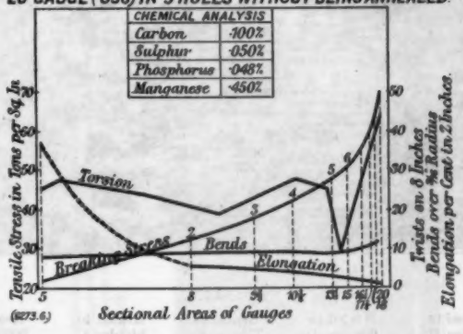


FIG. 5.

Microphotograph showing—left, 5 gauge rod; and right, the same drawn to 10 gauge wire. Magnified 120 diameters.





For the correct drawing of wire it is absolutely necessary that the metal should pass through the draw-plate with even lines of flow, so that if any set of points across a wire be taken in a plain section, as shown by *p p* in Fig. 2 (*a*), these should appear in the same plain section across the reduced wire, at *r r*. If for any reason the core of the wire lags behind the outer layers in flowing through the draw-plate orifice, then the points will not come in the same plane section in the reduced wire, but will be as shown at *l l*, Fig. 2 (*b*), after passing through the draw-plate. If the skin of the wire lags behind the core in passing through the hole then the points of the plane section at *p p* will be in the relative positions shown by the dotted curve, at *s s*, Fig. 2 (*c*).

The commonest defect comes under the second category where the core lags behind the skin, giving the well-known phenomena of "cuppiness" in wire, which means that the core is actually fractured, as shown by Fig. 3, before the outer part of the wire is affected. The photo-micrograph shown is a good illustration of "cuppiness," the cause of the fracture being due to a hard core in the wire of a segregated high carbon content. In this wire the incipient cups show up about every ¼-in. of its length. The phenomenon of "cuppiness" in wire, therefore, can be brought about by any defect in the steel or method of manufacture which causes uneven "flow" of the material through the draw-plate. It hardly needs to be stated that incipient "cuppiness" in wire causes extreme brittleness.

Fig. 4 well illustrates what happens when mild steel is crushed and made to "flow." On the left side of the micro-photo the full shape of crystals will be seen, but as those pass along towards the right it will be noticed that they are crushed and elongated, so that the crystals on the immediate left of the photo show simply as drawn-out white threads.

The correct shape of the hole shoulder is very important as affecting the proper drawing of the wire, and also the pull required to carry it through the draw-plate. The shape of the hole also depends upon whether hard or soft steel is being drawn. Generally a parabolic curve

* Abstract of paper read before the Liverpool Engineering Society, February 18, 1920.

covering the length $a\,b$, Fig. 1, gives the best results, but this shape is rather difficult to obtain in practice.

The pull required to draw a piece of No. 5 gauge rod down to 8½ gauge runs to about 1,600 lb., and from experiments made about 69 per cent. of this is used in compressing the wire, the remaining 31 per cent. being spent in overcoming the friction between the wire and the walls of the hole. The pull on the wire may

The reduction of area per draft may vary from about 40 per cent. in heavy gauges down to 20 per cent. in lighter gauges for mild steel. In hard steel the reduction is less than these amounts.

Effects of Wire-drawing on Physical Properties of Steel.

The chief alteration in the physical properties of steel when drawn to wire is an increase in its tensile strength and a reduction in its elongation. In Fig. 6 curves are shown which exhibit the changes in the tensile strength and elongation of mild steel wires having the chemical composition as shown on diagram. It will be seen that the No. 5 gauge rod as it comes from the rolling mill has a tensile strength of 27 tons to the square inch. In drawing down to 8½ gauge this has increased to 42 tons, and at 10½ gauge to 48 tons; 12½ gauge to 53 tons; 14 gauge to 65 tons. Its elongation in 2 in. following from 32 per cent. at No. 5 gauge, down to 5 per cent. at 8½ gauge; and then being reduced to 1 per cent. when the wire comes to 14 gauge. The elongation curve for $\frac{l}{\sqrt{area}} = 4$, that is, when $l = 3{\cdot}5d$ has also been plotted.

As showing the variation in tensile strength that it is possible to obtain by varying the drafts, curves are shown in Fig. 7 for a wire that has been taken down by lighter holes. In this it will be noticed that the tensile strength increases much less rapidly than when the wire is heavy-holed. From the diagram it will be seen that when the wire has arrived at No. 18 gauge, it has only about the same tensile strength as No. 14 gauge wire in heavy holing. From the above illustrations it will be observed that very considerable latitude can be obtained in the tensile strength of a wire according as it is heavy or light-holed.

Three diagrams are given which exhibit some of the different properties which it is possible to obtain by

Fig. 8. WIRE DRAWN FROM UNTEMPERED ROD 4½ GAUGE (·222) TO 10 GAUGE (·129).

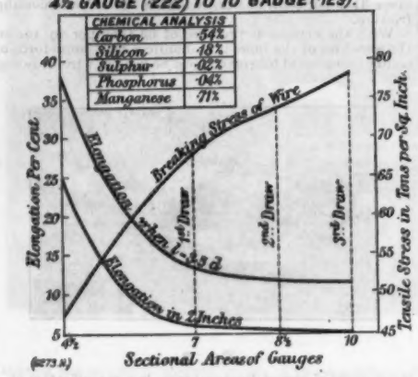


Fig. 9. WIRE DRAWN FROM 5 GAUGE (·212) UNTEMPERED ROD TO 30 GAUGE (·012) IN 18 HOLES TEMPERED AT 8 GAUGE (·160) AND RETEMPERED AT 16 GAUGE (·063).

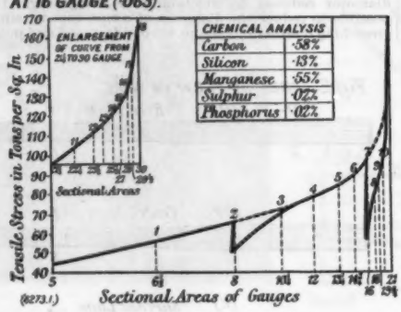


Fig. 10. WIRE DRAWN FROM 4½ GAUGE (·223) UNTEMPERED ROD TO 31 GAUGE (·0116) IN 18 HOLES, TEMPERED AT 8 GAUGE (·160) AND RETEMPERED AT 16½ GAUGE (·060).

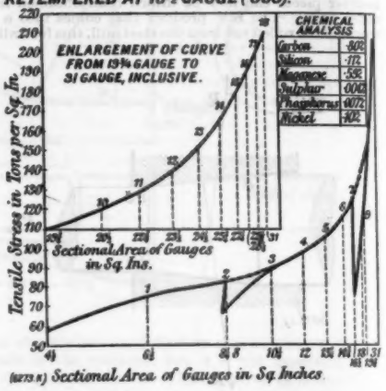

CHEMICAL ANALYSIS
ENLARGEMENT OF CURVE FROM 13¾ GAUGE TO 31 GAUGE, INCLUSIVE.
Tensile Stress in Tons per Sq. In.
Sectional Area of Gauges in Sq. Ins.
Sectional Area of Gauges in Sq. Inches

Fig. 11. TENSILE CURVES FOR HARD AND MILD STEEL.

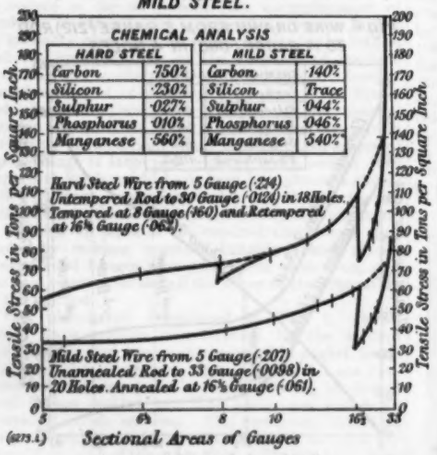

CHEMICAL ANALYSIS
HARD STEEL
Carbon ·750%
Silicon ·230%
Sulphur ·027%
Phosphorus ·010%
Manganese ·560%
MILD STEEL
Carbon ·140%
Silicon Trace
Sulphur ·044%
Phosphorus ·046%
Manganese ·540%
Hard Steel Wire from 5 Gauge (·224) Untempered Rod to 30 Gauge (·0124) in 18 Holes. Tempered at 8 Gauge (·160) and Retempered at 16¼ Gauge (·062).
Mild Steel Wire from 5 Gauge (·207) Unannealed Rod to 33 Gauge (·0098) in 20 Holes. Annealed at 16½ Gauge (·061).
Tensile Stress in Tons per Square Inch.
Sectional Areas of Gauges

Fig. 12.

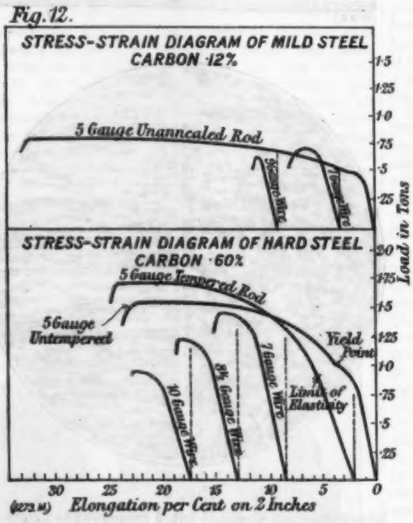
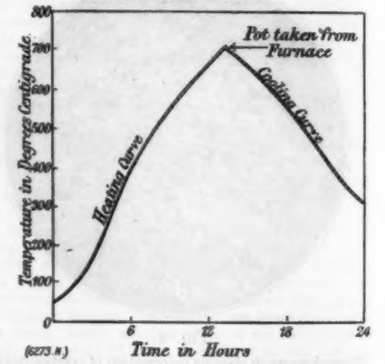


Fig. 13. TEMPERATURE CURVE OF WIRE IN AN ANNEALING POT.



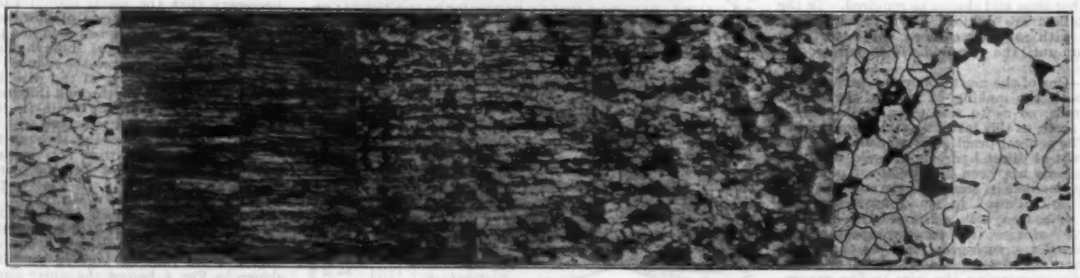


FIG. 14.

Rod as rolled.	16-Gauge wire as drawn.	Heated to 540 deg. C.	Heated to 600 deg. C.	Heated to 735 deg. C.	Heated to 840 deg. C.	Heated to 900 deg. C.	Heated to 1010 deg. C.	Rod heated to 1000 deg. C.
Tensile strength in tons per sq. inch.	64·43	34	28·25	25·46	25·20	25·25	25·05	
Elongation on 2″	2·5	12·5	20	25	22·5	22·5	22·5	
Twists on 8″.	46	80	103	117	126	142	88	

Micro-Photographs showing Changes in Structure of 16-Gauge Wire when Heated from 540 deg. C. to 1010 deg. C. Magnified 200 Diameters.

with safety be allowed to amount to about 75 per cent. of its breaking load. The speed at which the wire travels through the hole varies according to the diameter, but as an illustration it might be mentioned that No. 10 gauge will pass through the hole of the draw-plate at the rate of about 500 ft. per minute. For hard steel the speed is considerably less.

Fig. 5 shows the structures which respectively obtain in the 5 gauge rod before drawing, and, as it comes from the rolling-mill, and the same rod when drawn into 10-gauge wire.

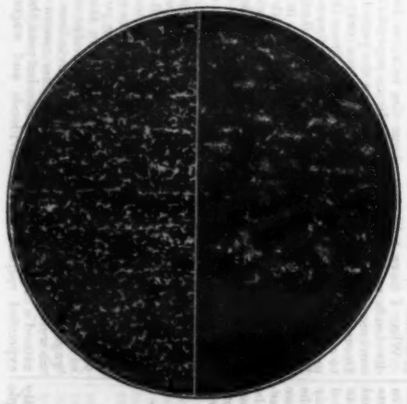


FIG. 15.

Micro-photograph showing the effect of tempering on a 0·69 per cent. carbon rod: Left, untempered rod, showing pearlite and ferrite; right, tempered rod showing structure entirely changed to sorbitic. Magnified 200 diameters.

FIG. 16.

Micro-photograph showing sorbitic structure of 5-gauge tempered rod and the same drawn to 13-gauge wire. Magnified 200 diameters.

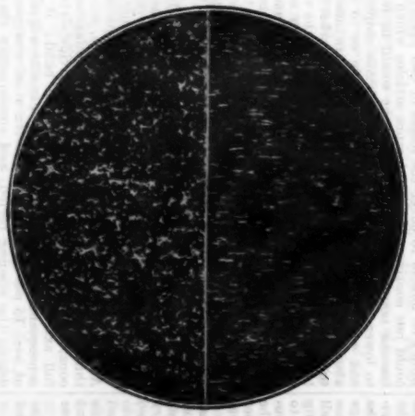


FIG. 17.

Micro-photograph showing: Left, 0·69 carbon, 5-gauge untempered rod, and right, the same rod drawn to 13-gauge wire. Magnified 200 diameters.

FIG. 18.

Micro-photograph of edge of hard steel rod after tempering showing partially decarburised surface. Magnified 100 diameters.

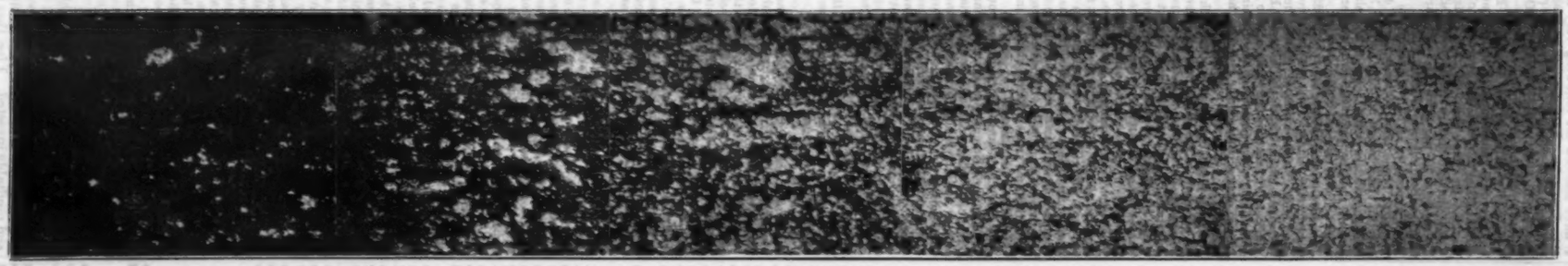


FIG. 19.

Panorama group of micro-photographs showing the gradual change from martensite to sorbite over a length of ·125 m. in the tempering of a 0·71 per cent. carbon and 0·84 per cent. Manganese steel rod. The right hand is almost complete martensite while the left hand is nearly all sorbitic.

increasing the carbon content of the steel. In Fig. 8 it will be noticed that the tensile strength of a 0·54 per cent. carbon rod has increased from 47 tons at *No.* 4½ gauge, in having been drawn three holes, up to 78 tons at No. 10 gauge; whilst the elongation in 2 in. has fallen from 25 per cent. down to less than 1 per cent.

In Fig. 9 the tensile curve is shown for a 0·58 per cent. carbon steel drawn from No. 5 gauge to No. 30 gauge with two temperings. The first tempering is at No. 8 gauge, where it will be observed that there is a considerable drop in the tensile strength, this rapidly picking up again at the next two drafts. Re-tempering takes place at No. 16 gauge, with a consequent big fall in the strength of the wire. Drawing is then carried on to No. 30 gauge, where the tensile strength mounts up to 170 tons to the square inch.

It is interesting to study the gaps in the tensile curve made merely by tempering and re-tempering. By running a dotted line across the top of the gaps a continuous curve is obtained which seems to show that if the steel would stand the wire-drawing treatment the curve would continue along in this way. The tempering and re-tempering process seem to give the wire a lift up, as it were, so as to enable it to be drawn down to the finer gauges without being broken or suffering from over-drawing.

In Fig. 10 a tensile strength curve is shown for steel of 0·80 per cent. carbon. Here, it will be seen, that the rod, as it comes from the rolling-mill, has a tensile strength of 58 tons to the square inch. In drawing from the rod, with tempering at No. 8 gauge and re-tempering at No. 16½ gauge, the tensile strength mounts up to 210 tons by the time the wire is reduced to No. 30 gauge.

In Fig. 11 tensile curves are shown of hard and mild steel both drawn to the same scale. These will show at a glance the differences that are set up in the strength of wire which is drawn from 0·75 per cent. carbon steel in the one case, and 0·14 per cent. carbon steel in the other.

Bends.—In Fig. 7 a curve of bends is also shown. These, it will be noticed, increasing slightly as the wire is reduced in diameter.

Torsion.—There is no physical property of wire which is so sensitive to any form of influence as that of torsion, this property being affected by the condition of the material, method of tempering, method of wire-drawing, and any form of low temperature treatment, such as galvanising or tinning. This is particularly true in dealing with the higher carbon steels.

In Fig. 7 a curve is shown which explains the alteration of torsion from the rod in No. 5 gauge right up to No. 20 gauge wire. It will be noticed that there is a peculiar drop when the wire gets to about No. 14 gauge. Whether this is a critical state in the range of wire-drawing it would be unwise to say, as sufficient experiments have not yet been carried out to confirm the results.

Stress-strain diagrams for mild and hard steel wire taken on a 10-ton Buckton testing machine are shown in Fig. 12. The chief characteristic observed in the mild steel diagram is the great reduction in the elongation as the wire is reduced in diameter. In the curves for hard steel it will be noticed that the untempered rod shows a definite yield point, but in the tempered rod it will be observed that no yield point is shown on the curve. This is not only true for tempered rod, but taking the curves for drawn wire on both the diagrams it will be seen that there is no clearly defined yield point. Also, it should be noticed that it is not easy exactly to define the limit of elasticity in any of the cases shown. Strictly speaking, however, the limit of elasticity should be at the point where the straight line becomes tangential to the curves as shown in the No. 5 gauge tempered rod.

The operation of wire-drawing on steel, it might be mentioned, has the effect of increasing its electrical resistance, so that in practice it is necessary to anneal wire that is to be used for telegraph and similar purposes.

ANNEALING AND TEMPERING.

The annealing of mild steel wire usually takes place at such a stage in the process of drawing as to bring about the mechanical properties required in the finished wire. The wire may be furnaced as it passes continuously along on its way through the galvanising process for telegraph and fencing purposes, or it may be annealed in a muffle

or semi-muffle furnace in bulk for such use as rivets, bolts, &c. Then for softer wire, which is required for drawing down to fine sizes or making into netting, closed pots are used, these latter being lifted ready charged into a special type of furnace, and removed into a cooling pit when they have attained the required temperature.

A heating and cooling curve showing the changing temperature over 24 hours is shown in Fig. 13. The pot in this case weighed 35 cwt., and its wire contents about 30 cwt., so that the diagram really explains what is taking place in the way of changing temperature in the centre of a mass of metal of about 3½ tons.

It is fatal for thin wire to be overheated in the presence of even small quantities of air, as the surface quickly oxidises, and the wire becomes what is known as "baked" by the oxide welding together.

Wire is readily affected by quite low temperatures. The following table shows the changes that take place when a No. 16 gauge 0·12 per cent. carbon mild steel wire is heated from atmospheric temperatures to 1,010 deg. C.

Time of Heating in Minutes.	Highest Temperature. Centigrade.	Time held at Highest Temperature in Minutes.	Time of Cooling in Minutes.	Tensile Strength. Tons per Sq. Inch.	Elongation per Cent. in 2-inch.	Twists in 8-inch.
Wire as drawn	—	—	—	64·43	2·5	46
15 ..	540	15	50	34	12·5	80
25 ..	600	25	50	28·25	20	103
60 ..	735	10	60	25·46	25	117
120 ..	840	10	60	25·2	22·5	126
120 ..	900	10	100	25·25	22·5	142
180 ..	10,10	10	130	25·05	22·5	88

From the table it will be seen that the wire attains its greatest softness somewhere about 850 deg. C.

Fig. 14 is a group of nine micro-photos showing the changes which take place in the micro-structure, mild steel rod (No. 1) when drawn down to 16 gauge wire (No. 2), and then as heated from 540 deg. C. to 1,010 deg.C (Nos. 3 to 8). By comparing Nos. 8 and 9, it will be seen that the 16-gauge wire can be brought back again to practically the same condition as the rod if sufficiently heated. The change in the physical properties against the corresponding structure will also be noticed.

Tempering.—What is known as the "patenting" process in wire manufacturing, consists of running the wire continuously through a tube furnace and cooling it in air or some other medium, with the object of regulating the rate of cooling so as to set up such a structure in the steel as will give maximum strength and toughness. The structure which gives these desirable qualities is what is known as "sorbitic." If the rate of cooling is too quick, then the hard "martensitic" structure is formed, which results in brittle wire. With slower cooling, the structure becomes either "sorbitic-pearlite" or "pearlitic," and with very slow cooling the final transformation takes place, producing the normal "pearlite-ferrite." The last three mentioned structures give successively decreasing tensile strength. It will be seen that the above method of tempering is of a positive character, as instead of cooling the steel very rapidly and tempering it by re-heating, the required condition of the steel is engendered by simply regulating the rate of cooling.

As showing the great change that takes place in the structure when a rod is tempered Fig. 15 is a good illustration. In the right hand half of the micro-photo it will be observed that the ferrite has been almost completely absorbed, the structure becoming sorbitic. Fig. 16 shows the structure of tempered rod and the 13-gauge wire drawn from the same. Fig. 17 is an extremely good micro-photograph, showing both the structure of the untempered rod and the same when drawn into 13-gauge wire. In the process of air-tempering the surface of the rod or wire becomes partially decarburised (Fig. 18). Ignoring losses through the formation of scale, this is rather an advantage as it gives a softer skin for wire-drawing purposes, which enables the metal to "flow" through the draw-plate hole somewhat easier.

A somewhat remarkable group of micro-photographs is shown in Fig. 19, these being taken from a steel rod which was erratic in tempering, some parts being hard and some tough. The micro-photographs show that the rate of cooling was just on the border line between giving a martensitic structure on the one hand, or a sorbitic on the other. By careful testing, a piece of rod ¾ in. long, was found which gave the hard structure at the one end and the tough structure at the other. The structure over the range of ½ in. is shown in Fig. 19. Whatever may be said with regard to the formation of troostite it would appear from the micro-photograph that all the dark areas shown from one end to the other are of the same structure.

(To be continued.)

A GERMAN INDUSTRIALIST'S VIEWS ON SOCIALISATION.

Address to the Employees of the Allgemeine Electricitats Gesellschaft, by FELIX DEUTSCH, *Chairman of the Board of Directors.*

(Concluded from page 704.)

But even if all these figures are accepted, it is always alleged that this small share of the profits flows into the pockets of a few capitalists, who hold the shares and thus accumulate gigantic sums.

This contention is equally incorrect, as the following figures clearly show: In order to obtain some guidance as to the distribution of the share capital, I have ascertained the total amounts of shares announced for voting at the general meetings of some companies and large banks. I have selected the following very large undertakings; (1) Deutsche Bank; (2) Disconto-Gesellschaft; (3) Dresdener Bank; (4) A.E.G.; (5) Gelsenkirchener Bergwerks-A.-G.; (6) Phœnix A.G.—and found the following figures:

At the meeting of the Deutsche Bank 11,600 shareholders were represented, holding between them 47 per cent. of the capital, the average holding being 11,000 marks. In the case of the Disconto-Gesellschaft, 8,434 shareholders were represented at the meeting. These held 27 per cent. of the share capital, and the average holding was 10,000 marks. At the Dresdener Bank meeting, 10,525 shareholders took part in the voting. These held between them 40 per cent. of the capital, the average holding being 8,300 marks. At the meeting of the A.E.G., 8,600 shareholders were represented, holding between them 40 per cent. of the share capital, and the average holding was 9,250 marks. In a similar way it appears that 6,323 shareholders took part in the voting at the general meeting of the Gelsenkirchener Bergwerk-A.-G. They held 50 per cent. of the share capital, and the average holding was 13,000 marks. Finally, in the case of the Phœnix A.G., the shareholders represented at the meeting held 40 per cent. of the share capital, the average holding being 8,600 marks.

From these figures it appears that altogether only 40 per cent. of the shares were represented at the general meetings; but if we take into consideration that the provincial banks and bankers do not specify each individual shareholder, but announce merely the total of the shares they represent, and that finally the large majority of shares remained unrepresented because they were divided among an enormous number of small private people, it must be clear that the average holding of each individual shareholder can hardly amount to more than 3,000 marks to 5,000 marks. But this distribution means neither more or less than that the bulk of the German share capital is divided among so huge a number of individual shareholders, that it must already be considered as "socialised."

It is widely—and entirely erroneously—believed that the accumulation of capital in Germany is a consequence of the development of limited liability companies; this is quite wrong. Commerce and private industry represented by such people as before the war, pursued the business of apothecaries, saddlers, goldsmiths, locksmiths, butchers, small contractors, publishers and printers, and those engaged in outfitting and textile trades, &c., import and export of goods, in horse and cattle dealing, &c., created the greatest part of our property before the war.

The development of limited liability companies depended on the participation of the capital earned and saved by these people.

It may be objected that in the above *resume* as to the division of the profits no account has been taken of the "secret reserves." These reserves do indeed exist, but the case is this: They have originated in the writing-off of machines, tools, patterns, and in the careful estimates of the value of investments and stocks. Without these precautions there could be no guarantee for the continued existence of a company, no security for dividends to the shareholders nor for the existence of employees and workmen. These secret reserves enable a company to follow up and to utilise the never-ending progress in the whole world, to bring their manufacturing processes up to a high level and to obtain for the sale of their products an ever wider market.

I shall illustrate this to you by an example: Formerly we, like all other manufacturers, were in the habit of using machine tools, each of which required the services of one man. Well, one day new machines were offered to us from America, which require the services of only one man for three machines; this meant a considerable saving, and we could not hesitate to incur the great expense for the purchase of these new machines. But the technical development did not stop there; two or three years afterwards America brought into the market a fresh type, of which nine machines could be served by one man. It is true that a workman of a higher intellect was required for these machines, whilst the older type had required nothing but purely mechanical attendance. It stands to reason that the large expenses for these fresh purposes could only be borne by a concern, which had a sufficiently large turnover to enable it to make the fullest use of these machines. This was the case in the A.E.G. factories: they had for their products a market which included the whole world, and in the whole organisation of the A.E.G., consisted of approximately 400 branches. They were thus enabled to take the risk of scrapping machines bought only a few years previously and replacing them by the improved type, but we could only take this step because we had already written off the former machines, otherwise we would have been unable to pay also for the amortisation for the latest types, and we would have been forced to abandon the business to more intelligent and cautious competitors, and would have found ourselves unable to compete effectually with them.

You will justly inquire, what has been the result of all this huge expenditure?

Our statistics show that in small motors we sold:—

	Machines.
1903–4	13,000
1904–5	15,000
After introduction of the new machines:—	
1909–10	47,000
1913–14	89,000

This shows that these huge sums were intelligently and profitably invested. I feel that by this one example I have already sufficiently shown the necessity for the creation of secret reserves. But this does not by any means exhaust the subject.

A company which is not in a position to spend considerable sums for patents, new constructions and experiments cannot retain its position and its reputation. Thus we have—to give you an illustration—spent 1,000,000 marks in developing the Nernst lamp; and the experiments on steam turbines up to the moment when their construction could be considered as definitely fixed, cost us over 5,000,000 marks. We were entitled to spend such sums on experiments because we knew that, if we succeeded we should obtain a turnover, which would quickly compensate us for the amount expended, whilst if we were unsuccessful, the expenditure could be covered from our reserves without affecting dividends, salaries or wages. Our expectations have also in this case been fulfilled; up to the outbreak of war we have sold annually steam turbines of a value of about 30,000,000 marks, but this would have been impossible had we not been able to draw on our secret reserves for the expensive experiments which were indispensable.

The importance of the secret reserves reaches still further; it goes to the very foundation of an enterprise, and affects therefore the fate of its employees and workmen; for they alone make an adjustment between good and bad years possible; if we do not create reserves during the years of favourable constellations, every unfavourable wind would threaten our existence. We would be unable to cover the losses of bad years; we could not continue to manufacture articles which had become temporarily unprofitable, but would be forced to lower salaries and wages, nay, to dismiss employees and workmen. The reserves alone enable us to keep above water and wait for better days; we are indebted to them for the possibility of protecting the market from being disturbed so that a certain steadiness in the value of our shares can be counted upon, which is for us an urgent necessity because we have to appeal to the market for fresh capital required by our ever-growing undertakings and its confidence in us is indispensable for these purposes. Great fluctuations in the dividends would frighten away capitalists and would make the procuring of new money very difficult, if not impossible. Such alarms could not be avoided without reserves; only because we had always before our eyes the possibility of an unfavourable turn of affairs have we emerged stronger and stronger from the catastrophes suffered by other companies such as Schuckert, Helios, Kummer, &c.

It is no doubt known to you that many companies in America have been severely criticised because, without thinking of the future and the possibility of unfavourable constellations they distributed every year dividends to the full extent of the profit they had on hand; it was consequently inevitable that after a year with a dividend of, say, 15 per cent. no distribution at all was possible during the ensuing period, and consequently that, to the dismay of the shareholders, the price of the shares fell precipitately—partly because persons in touch with the working of the companies and consequently well informed of the internal situation could easily initiate a pernicious gamble in the shares.

I believe, therefore, that there can be no doubt as to the absolute necessity of creating strong internal reserves, and even a Socialist administration will not be able to do without them; for we must not overlook the fact that "socialism" and "capitalism" are by no means contrasts in this respect. Both demand identical forms of production; they will consequently be unable in practice to do without the same, or, at least, similar forms of organisation. The only thing that socialism can rationally demand unless the term socialisation is to remain an empty phrase, is that organisation of our industrial life which will obtain the greatest possible benefit for the population as a whole.

I hope to have convinced you that, even without losing the war and without a revolution, we were on the way, solely through the vital force of our natural development, to realise all that which democracy for decades past has aimed at in its demand for socialisation of our means of production, namely, the socialisation of both the profits and the capital, but without, by precipitate experiments, turning our economic life upside down and thereby risking its complete ruin!

Well, this natural development has been most seriously disturbed and endangered by the revolution and by the introduction and the execution of the Hindenburg programme.

What I have told you about the relation between dividends and the direct and indirect expenditure on workmen and employees refers only to the period up to December, 1917, because my compilation only refers to a period of ten years up to that point. Since then the proportion has been considerably altered for two reasons. We were faced, first of all, by a sudden rise of all expenditure in consequence of the hairbrained manner in which the military authorities placed their orders with industrial establishments. They fixed the cost of production as the basis for the calculation of the prices of many commodities, the industrialist was accordingly no longer forced to be as careful as formerly with regard to the demand for increases in wages and salaries, since every such rise increased the profit in the same proportion, in which the original cost of production was increased. At the same time, the inflation as well as the fall in our "Exchange"—caused by the cessation of our exports—and the growing difficulty of feeding the people, resulted in a continuous fall in the purchasing power of our money, which, in its turn, led to a rise in the price of the necessaries of life and thereby to further rises in wages; we had thus got into a vicious circle from which we were unable to break out! The other reason which caused a dislocation of the proportion between the sums expended respectively in dividends and wages, &c.,

was created by the situation caused by the occurrences of November 9, 1918. In the chaos of the revolution the arrangement had to be abandoned which had been the outcome of many months' negotiations between the leaders of the Labour-Unions who had staked their reputation on maintaining an understanding between employers and employed.

With the annihilation of all authority and the loosening of all ties, even the otherwise commonly-recognised authority of these Unions could not be maintained—and employees and workmen raised their demands to figures which they would themselves have considered utterly unreasonable a few weeks earlier. The class egotism of the workmen took an attitude so entirely bereft of all reason that they had to be warned by one of their own leaders not to dishonour the revolution by converting it into a fight for wages. But in spite of the immensity of their demands which seriously jeopardised the continuation of industrial work, these had finally to be conceded less worse befall, at that serious and danger-threatening period—and after prolonged negotiations an agreement was concluded between these unions, the committee of arbitration and the Union of Berlin Metal Industries.

The following figures show the average monthly salaries and wages paid at different periods:—

Employees.

	31-7-14.	31-10-16.	31-10-18.	1-1-19.
	Marks.	Marks.	Marks.	Marks.
Male ...	216·00	300·00	505·00	560·00
Female ...	94·60	109·00	210·00	253·50

The figures include the war bonus of December, 1918, and a "debt allowance" on December 10, 1918.

This constitutes for the A.E.G., on the basis of the number employed in December, 1918, a yearly increase of over 19,000,000 marks, as against 1914, thus:—

	Marks.
1914	12,204,000
1919	31,436,000
Increase	19,232,000

In these amounts the sums paid as participations in profits, and as commissions on turn over are naturally not included.

The increases of salaries fixed lately by the Committee of Arbitration show a further addition of some 7,000,000 marks to 8,000,000 marks.

The highest average wage of all categories of workers amounted per hour to:—

1913-14.	10-1-17.	11-10-18.	Fixed by the Union.
Marks.	Marks.	Marks.	Marks.
0·59	1·08	1·51	2·21

The percentage increase of Union wages amounts for all categories of workers, as compared with 1913-14 to 270 per cent., as compared with 10-1-17 to 115 per cent., and as compared with 11-10-18 to 50 per cent.

Taking the wages as last fixed by the Union as a basis for calculation, we find, with the relative number of workers in the A.E.G., an expenditure in wages of 142,000,000 marks, against 37,000,000 marks in 1913-14, showing an increase of 105,000,000 marks; as compared with the conditions on October 11, 1918, there is an increase of 46,000,000 marks.

Now try to imagine, what a change the whole picture has undergone! Nothing is left of the yield of 5 per cent., and nobody, neither banks nor capitalists—if any such should be left after the grotesque taxation plans which are being seriously considered by the Government—will be able to place any money at the disposal of the industry.

We know already that all mining concerns are working with large losses, that the credit balances, which the great concerns still possessed with the banks a few months ago, are exhausted and that the banks cannot take upon themselves the responsibility of placing further credits at the disposal of industrial concerns.

How does the economic position in Germany present itself at the present moment, and is it capable of carrying such a burden?

The armistice concluded with the Entente powers means a newly-tightened blockade. Sea traffic with the Scandinavian Nations is blocked, no necessaries of life reach us from Roumania or the Ukraine. The orders placed by our home authorities have been cancelled and only limited quantities produced may be produced at proved original cost in order to obviate large dismissals of workers. Our railways are in a deplorable condition. The hasty retreat of our troops, the enormous overburdening of our rolling-stock during 4½ years, and the impossibility of making the necessary repairs in an orderly manner, and at the proper moment, have led to a complete breakdown of traffic. Add to this that the Entente has stipulated for the handing over of 150,000 cars and 5,000 locomotives. Under these conditions one is entitled to say that the shortage of coal is in a great measure a question of transport. Certainly not solely a question of transport, but also a question of production. After the armistice the French and Belgian prisoners of war who were up to then employed in mining operations refused to work any longer in the mines and prevented even the Russian prisoners, who were willing to work in the coal mines, from continuing this occupation. As no new workers offered themselves, and as the soldiers also, who returned from the front, despised the work in the mines, the production of coal has since then decreased by leaps and bounds. If this situation continues all industrial activity must cease—the factories must be closed and the workers dismissed. The increase of wages, which they have forced through by the strongest pressure and threats of strikes cannot protect them from this fate.

The position in regard to raw materials is also most critical. Our hope of obtaining these has been deferred to a far future by the fact that our whole mercantile marine has had to be handed over to the Entente. It is to-day impossible to forecast when we may obtain raw materials, as also what quantities may be allowed to us—and without raw materials we cannot exist. The prices of these materials—of which we, of course, possess only very limited quantities, have reached a fantastic height.

	Per Cent.
Copper has risen about	270
Aluminium has risen about	310
Tin has risen about	345
Zinc has risen about	160
Steel has risen about	200
Glue has risen about	340
Varnish has risen about	565

Whilst many raw materials are to be had abroad at low prices, for instance, indiarubber, which commands a lower price in the world market than before the war, but the importation of this into Germany is not permitted.

Another point appears to me worthy of being discussed in detail. Lately, when discussing questions of salaries and wages, demands for scales of salaries have been formulated for different ages and groups of employees. If such demands were conceded we would arrive at a complete bureaucratisation of our economic life—a State of affairs which I assume a great majority among you would hardly be prepared to agree to. In State employment every category of employees and every individual among them has to fulfil a special strictly-defined work, and besides their salary these employees were compensated by orders and titles and small pensions. Under such circumstances, one may be able to work for different departments with a scale of salaries whose steps the individual climbs in the course of years, which however, is so modest, that you have no reason to wish to see this system transferred to the employees of private concerns. You cannot overlook that for those who have to find work for their employees, dividends for their shareholders, and payable occupation and a guaranteed existence for themselves, a different stamp of men and different methods are indispensable. We, in the A.E.G., have from the beginning worked on the principle of allowing all those workers who are instrumental to the profitable working of our concern, to participate in the profits of the company. We have given a commission on their sales to our salesmen and travellers, a share in the profits of their products to our department chiefs in order to make them personally interested in delivering the greatest possible quantity of finished material from their departments, we have given the heads of departments in Berlin and the chiefs of our branches a share in the profits just the same as our managers and directors receive their share of profit according to the amount of profits distributed as dividends.

We have considered that this procedure resulted in the mutual benefit of our co-workers and our company, and we have at the present moment over 1,000 employees who are, in one way or another, participating in the profits of the concern. Only those employees whose utility for the concern is not demonstrable by figures, because their work is more of a quantitative than a qualitative nature, receive fixed salaries, which, however, are far and away above the scales of salaries granted to the employees of the State—so that none of you can have a money interest in exchanging his position in the A.E.G. for a place in the public service.

But even as regards posts with fixed salaries we do not proceed automatically. A capable "constructor" must according to capacity be more highly rewarded than one of smaller utility, just the same as an experienced book-keeper or any one employed in other directions must be rewarded according to his merits. Furthermore, we take care that these categories, too, are in a measure participators in the profits of the concern by granting special bonuses in favourable years, after the general meeting has taken place.

In this connection I should like to point out that with us—as with most large institutions—there are at all times a greater number of highly-paid positions at our disposal than we can fill with fully-qualified candidates. I do not mean to say that quite a number of candidates do not consider themselves fully qualified to fill such positions—but we have unfortunately only too often found out that there was a lack of the necessary experience, organising capacity and initiative, but every one of you has the possibility of attaining such positions and obtaining the corresponding income. I am therefore, of the opinion that apart from fixing an initial income which must represent a sufficiency for existence—and which I consider indispensable and practicable, the carrying through of the demands which I have discussed would not be of any benefit to you, but would be a distinct disadvantage to all capable employees.

And cannot we, after all, describe all contract work as a participation in profits? Every clever and industrious worker obtains thereby the possibility of reaping a considerable benefit over and above the normal wage, because he also, through his extra work increases the profits of the concern. I consequently feel safe in suggesting that in your own interest, as well as in the interest of our company, you will reject every system of salary which is based on any foundation differing from the one which we have now in use.

Before the war we exported about 40 per cent. of our total turnover to foreign countries. This part of our turnover is now lacking, and I am afraid it will still be lacking for a very long time. Thus, even if in consequence of the enormous rise in our wages, salaries and cost of materials, we raise the prices of our products in Germany higher and ever higher, we cannot hope thereby to compensate to any appreciable degree for the losses, which must result from the loss of our foreign business and the great reduction of our production caused thereby, which again conditions an increase in our original costs. It is just this circumstance which the socialist idealogues are wont to overlook, although this cannot be too sharply pointed out in the interest of employees and workmen.

If things continue to develop as they have done since November 9, 1918, if you all continue to make demands on industrial undertakings which these concerns are in reality unable to fulfil, then even the most unsophisticated workmen will soon understand the relation between the internal political economy of a country and its capacity of competing in the world's market—and equally the interdependence of this competitive capacity and his own, the workman's, welfare.

Unfortunately, this knowledge might easily come too late, at a time when there is nothing more to save and when Germany has lost her position in the world's market for generations to come. And if the "Autarkie" (i.e., economic self-sufficiency) which, as a consequence of the probable scarcity of raw materials at our disposal after the war has been suggested by some of our political economists as a subject for discussion, became an accomplished fact, millions of workmen who have formerly been employed in the production of our merchandise for export, would be unemployed, and would be forced to emigrate into happier countries where they would be, as their brothers were before the great development of our industries, cultural manure for foreign nations, and would have to work for foreign prosperity. You and your leaders should, however, not deceive yourselves about the fact that, with the general feeling, produced against us all over the world by the war, they would be rewarded by contempt and humiliations of every kind. This has ever been the fate of the people who have been forced to send part of their population into foreign countries because their own soil did not afford them a possibility of existence—and the German emigrant would have to expect into the bargain, the worst humiliations and persecutions from the members of his own class because to them he would only appear in the objectionable shape of a "wage cutter" or blackleg.

Finally, I wish to draw your attention to another very serious consideration; wages and salaries are so much higher in Berlin than in the provinces that Berlin industries become more and more incapable of competing against those which are domiciled in Bavaria, Saxony and Westphalia. Unless these conditions change soon, we shall have to choose—and you must make it clear in your own circles—only between two alternatives; we shall either be forced to close part of our factories, or to transplant them into the provinces. I need not explain to you what both these alternatives would mean to our employees and working men; they mean dismissals on the largest scale, unemployment, and the ruin of the Berlin industries.

In conclusion, we are neither able, nor do we desire to oppose ourselves to the current of the times which presses towards social reforms and will surely effect them. But I repeat what I have said at the beginning of this address; such reforms are only possible on the basis of sound and orderly economic conditions, they lead to the ruin of the individual and the community, if they are attempted on a shaky basis and in a rash, precipitate and amateurish manner. If by the facts and figures I have placed before you, I have succeeded in convincing you, that, in our present situation, we find ourselves on a declining plane; that exaggerated demands by employees and workmen cannot bring them any benefit, but may in a measurable distance of time bring our industry to a standstill, and themselves to unemployment, and that we must jointly endeavour to come to a basis which enables us to work conjointly in a mutually prosperous community—as we have done in the A.E.G. during the last thirty-six years—a community in which you participate by your confidence in the discernment of your superiors and their interest in your welfare; in which the company is inspired by the desire to maintain its honoured and generally-recognised position among the industries of the world and to promote also the interest of all of you conjointly with the development of our company—if, I say, I have succeeded in this object, then I am convinced that I have rendered a service of use to all.

THE ART OF SYSTEMATIC INQUIRY (RESEARCH), ITS PLACE IN INDUSTRY.*

By Dr. H. E. Armstrong.

In what does the Art of Inquiry consist? We must suppose that, like other arts, it has been evolved. It has been systematised only for a century or so, but its origin must go back to very early times, when intelligence was beginning to dawn upon mankind, for without inquiry progress is impossible. In imagination we may contemplate some such course as the following, in the case of the common material, limestone.

Limestone is distinguished by the abundance of caves in it. In early prehistoric times, man lived in these caves, and has left evidence of his presence in them. Whenever the use of fire in cooking food was discovered, within the cave the fireplace will often (if not always) have been built of limestone blocks. The limestone would crack and soften, and from time to time probably burned blocks would be thrown out as useless, and thus become exposed to the weather. Its peculiar

* Abstract of lecture delivered to the Ceramic Society at their meeting at Stoke-on-Trent, April 29, 1920.

behaviour in contact with water could not fail to be noticed—getting hot and smoking, falling to pieces, and finally broken down to a soft fine powder. The distinction between limestone and lime—between mild and caustic lime, must have been made very early. If the burned lime happened to be thrown on a sandy soil, rain would not only slake the lime but wash some of it down into the sand; the mixture would sooner or later become hard, and the first step would have been made towards the discovery of mortar. The discovery apparently was not made very early, for the Egyptians and even the Romans used to build without mortar.

Pyrite is another common mineral, which supplies the sulphur given off in burning coal; it occurs as golden yellow scales on many coals. The name is derived from the fact that when pieces are struck together, glowing sparks are produced, and it was doubtless used in very early times for procuring fire. Pieces of pyrite have been found together with the rudest forms of flint implements and other relics of human activity. Pyrite was certain to be valued enough to be collected and stored by prehistoric man. When left exposed, it soon weathers, becoming partly soluble in water, so that rain falling on a heap of the decayed material would wash some of it away. In case the washings collected in a pool near the heap, the dissolved substance would be deposited as the water evaporated during dry weather, green, glassy crystals being formed. The washed heap has a rusty appearance, and the material forming the crystals was long ago called green vitriol—vitriol being the general name given to a number of crystalline glassy substances. The early alchemists used to test everything they came across, and, fire seems to have been one of the first tests to be applied. On strongly heating green vitriol, dense white fumes are given off, which when condensed (by cooling) give a corrosive, strongly acid, oily liquid, known still as oil of vitriol. Testing the effect of this on various substances, it was found that when poured upon nitre, it gives rise to another volatile acid, which dissolves many metals, and hence was called *aqua fortis*, which is still used by jewellers to distinguish imitations from real gold, the latter not being acted on by *aqua fortis*. Sea salt, when acted upon by oil of vitriol, was found to give off fumes which readily dissolved in water. The fumes were termed spirit of salt, and the solution became known as muriatic acid, both of these names being still in common use. In this way the old workers were always proceeding from the known to the unknown.

The nature of the change undergone by limestone when burned was not discovered until early in the scientific era, by Black about 1755. But great as the growth of knowledge has been, the majority would remain incurious in face of a mountain of smoking, slaking lime. Embryologists tell us that every higher form of individual life becomes what it is, in its passage from the early stage corresponding to an egg, by a process of gradual development from an extremely low form. The same is true of society, we can see in it all the forms of far off times. And not only is mankind the proper study of man, but it is the only study in which any large number can take an abiding interest. Nature apart from man has little interest for most of us. Though most houses are built with mortar, scarcely any one cares what mortar is, but only what mortar does; at most it is so many parts of lime to so many parts of sand.

Little if anything has been done to develop and extend the art of inquiry; the teaching of the Church and of the schools for the most part has been frankly dogmatic, the pursuit of truth being evaded, not encouraged. The task before us is to overcome this lack of outlook.

The art of the potter, as now practised, can only have been acquired by trying experiments, in no way random, but based upon intelligent observation and the constant exercise of the imagination. The construction of the potter's wheel must have been an astonishing feat of discovery and invention thousands of years ago; probably it involved a whole series of discoveries and inventions.

The potter is proved by his works always to have been an unconscious investigator and discoverer. Noticing some particular effect, he has asked himself and ascertained what would happen if the conditions were slightly varied, and has thus unknowingly educated himself in the art of inquiry; in fact, he has constantly engaged in what we now grandiloquently speak of as research. The history of Palissy the potter is a record of research, and the Wedgwood Museum is full of proof that the pioneer worker in the potting industry was an experimenter of the first order.

Mr. Bernard Moore is a striking example of the born investigator. At the outset he had the idea before him that all colours should be obtainable from a single mixture by varying the conditions—and in his lustre ware he has all but realised this dream; reds shade harmoniously into blues, and the two become blended in most surprising ways, giving rise to colour forms of wondrous beauty and purity. In no other ware has the control been so fully demonstrated which the potter may exercise over his materials.

The war has stirred the spirit within the potter, and he with others now realises that the power to use knowledge—not knowledge itself—is power. And this power to use knowledge is scientific method—knowledge used with method to regulate procedure and to procure new knowledge.

The method of science is in no way peculiar—it is the judicial method, the method of the logician applied to practice, the method of the detective; Huxley called it organised commonsense. The shilling-shocker detective story is universally popular—because it deals with human doings. But who wishes to read a detective story dealing with the discovery of the nature of the crime committed, let us say, when iron rusts? Yet it may well be regarded as a murder of the cruellest kind, as the valuable strong metal is changed into a worthless powder. This is one reason why science makes so little headway in our society; another is that it is necessary to know a great deal, if effective use is to be made of science, the problems being rarely simple. But the principles of scientific method are of universal application and within the range of ordinary intelligence; it is these we need to bring home to the general public. Facts, more facts, all the facts in the world, if not what we ask for, is all we receive from the schools. The curse of books is too much upon us. The way knowledge is won, still less the way knowledge is to be used, is not taught. The teacher parrot is easily found: the teacher who will refrain from teaching, who will force his pupils to learn and develop them as observant, thoughtful, reasoning beings is almost unknown. No training being given in the art of inquiry, teachers cannot be expected to be inquirers or to lead others to inquire.

We shall only succeed in developing the intellectual faculties when we seek to develop them on the lines on which handicrafts are developed—through practice and not through prating. However many new buildings we may put up, we shall make no progress, unless we improve our methods of teaching and make them practical.

Huxley long ago summarised the position in saying that "The great aim of life is not knowledge but action." The knowledge gained in the schools should be of such kind, the training given so imparted, that both subserve the purposes of action, bearing in mind that, as Thring, a prince among teachers, insisted, "the whole human being is the teacher's care"—that we have to educate for the home as well as for wage earning.

Practice is always better than precept. In showing how beginners may be taught method, there must be some definite object in view, some definite problem to be solved, such as the examination of limestone, one of the commonest and most useful earthy materials. How would a detective proceed in such a case? He would endeavour to ascertain the facts of the case and pick up some clue which can be followed. Limestone is clearly the stone which contains or gives lime. Lime is made in lime kilns by burning limestone, either by putting alternating layers of limestone and coal in the kiln, or by passing the flames and heat from a neighbouring fire up through the kiln filled with pieces of the stone. The heat seems to enter the stone, but it seems strange that it should be expelled by wetting, for usually when substances are burned and reduced to ashes all life seems to go out of them. The lime burner can give many items of information, but none which seems to afford any very definite clue which can be followed, unless, indeed, he happens to say that the quantity of limestone put into the kiln is a good deal more than that taken out as lime. Dry chalk is weighed out in a suitable vessel (such as a porcelain crucible) and heated in a muffle furnace, then cooled and weighed again. The heating, cooling and weighing are repeated until no further change takes place. The loss is over 100 per cent., and repetition of the experiment would show that the same loss is always sustained, whatever heat may be applied, for the same kind of limestone. If students are being instructed, they should write out beforehand the reasons for making the experiment, and also record all they observed during the experiment. The results obtained also afford an opportunity of driving home certain lessons on the interpretation of numerical values, which have a bearing on ordinary business practice. From the actual results an average value is obtained. Usually about half the results of different experiments differ from the mean or average on one side and half on the other side. Further experiments would show that other materials, whether Bath or Portland stone or carboniferous limestone, would not differ materially from chalk. Only lias limestone is found to give a considerably smaller and very variable percentage of lime; but this variety is obviously "dirty" in appearance.

Thus the conclusion is established that the formation of lime depends on the expulsion of something from the limestone.

The stalactites and stalagmites are also found to give lime when burned, and lose nearly 44 per cent.—rather more than ordinary limestones lose. Calc spar or calcite—crystalline material filling up cracks in limestone rocks—also gives lime when burned, losing about 44 per cent. of its weight. It is difficult to resist the conclusion that this is the pure material of limestone.

It may next be asked how is limestone formed? Chalk when seen under the microscope is seen to be full of shell remains; shell remains are recognisable in most limestones, usually sea shells, but sometimes the limestone is largely composed of fresh water shells. Some limestones are full of coral remains, and coral is formed in the sea. Clearly limestone has been laid down under water, and it would seem that shells must be made of limestone. It is found by experiment that very good lime is obtained by burning almost any kind of shell, whether sea shells, fresh water shells, land shells, or egg shells, and the percentage of lime obtained is nearly as much as from limestones. The Challenger people dredged from the floor of the Atlantic, at depths of 2,000 ft. or more, an ooze very like chalk in appearance, and the minute shell remains in it were the shells of organisms living at the surface.

The lime obtained from limestones, if carefully weighed before and after slaking, is found to weigh more, about in the proportion of four to three, and nothing is lost on heating to a temperature at which water is easily driven off, but only at a considerably higher temperature. If this higher heating be continued, the lime again becomes "quick" and has the same weight as before.

In preparing mortar, the lime and sand are mixed with water, and some action takes place between the two solids. As regards possible action of water, it is easily found by shaking sand or lime with water, filtering off, and evaporating some of the clear liquid, that little if any sand is dissolved, but the lime water leaves a substantial residue. The solution has a sweet taste, and lime water is commonly given to babies. On shaking some finely-powdered limestone with water, filtering and evaporating the clear liquid, very little solid matter remains, limestone thus being far less soluble than slaked lime.

Discoveries have often been made incidentally by following up some chance observation. The X-rays and radium were chance discoveries, and so was the discovery of argon in air.

In making lime water, it is difficult to prepare a clear solution, for the clear liquid soon becomes covered with a skin when exposed, and in time quite a crust is formed on the liquid. Black, 150 years ago, concluded that the deposit was due to the lime attracting something, which he called fixed air, from the atmosphere. Black knew that calcareous earths, in their native state, effervesced violently when mixed with acids, whilst quicklime dissolved quietly, from which he concluded that limestone contained a large quantity of "fixed air" which it gave up when sufficiently heated. The modern student, having found that limestones effervesced with acids and, according to their purity, lost up to 44 per cent. in weight, would both measure and weigh the gas given off, and would subject the precipitate from lime water to similar treatment. He would have to think out ways of making the experiments.

The close correspondence thus established between the loss in weight when limestone is burned and the weight of the gas given off when it is dissolved in acid, taken in conjunction with the behaviour of lime water on exposure to air, and the similarity of the precipitate to limestone both on ignition and when dissolved in acid leaves little doubt that the conclusions already arrived at that limestone consists of lime in association with the gas called fixed air by Black.

Curiously enough, Black never carried his experiments so far as to establish the correctness of his conclusion by associating the gas given off on dissolving one portion of limestone in acid with lime formed by burning another portion and so reproducing the material of which limestones are mainly and calcite entirely composed. The modern student detective would necessarily seek to obtain this evidence. He would simply bring the gas in contact with lime water, and finding a precipitate produced, he would prepare enough to determine its precise nature when heated and when dissolved in acid, and thus establish its identity with Black's fixed air.

But instead of passing the gas directly into lime water, having heard that ordinary so-called soda water is made by passing similar gas into water he might for convenience add soda water to lime water. Finding a precipitate was produced, he might go on adding the soda water, hoping to produce more. Then would come the chance discovery that the precipitate is dissolved by excess of the solution. This important result affords a clue to the deposition from hard waters, and to the production of caves in the limestone.

The foregoing demonstrates the way in which the art of inquiry may be taught, how question after question may be asked, and the answers obtained by direct experiment. Such training develops habits of thought and the habit of looking into things, and the tendency is thus acquired to ask for definite evidence in proof of statements made.

Proof has already been given of the value scientific assistance may be to the pottery industry through the work done in connection with the production of hard porcelain. Early in 1915 the Governors of the Stoke Pottery School, together with representatives of the pottery manufacturers of the district, asked the Department of Scientific and Industrial Research for assistance in carrying out an inquiry into the methods of making hard porcelain similar to the domestic ware produced on the Continent. They had felt the competition of Continental countries and especially of Germany, which was sending large quantities of cheap translucent ware into our markets and especially into America. The department appointed a committee to go into the matter, and it was arranged that the inquiry should be carried out by Dr. Mellor and Mr. Bernard Moore at Stoke, the department undertaking to pay a sum of 7,500*l.* plus three-quarters of the other costs of maintenance. Owing to difficulties with labour and materials it was not until the end of 1915 that Dr. Mellor and Mr. Moore were able to get well under way, and in the early part of 1916 they were able to carry out their work on the manufacturing scale. The materials were to be of British origin, and the method of working was to be such as could readily be undertaken by a workman accustomed to the more plastic English clays. It was desirable that the ware should be capable of being fired in an ordinary English oven. The methods of decoration and the palette of colours had to be considered, and the cost of the ware was not to exceed that of the foreign ware with which it would have to compete. Eighteen months after the beginning of the experiments the difficulties had been largely overcome, and marketable table ware produced. About half a dozen firms are preparing to produce hard porcelain commercially.

A British Refractories Research Association was incorporated and registered as a limited liability company quite recently. It is to be hoped that those who conduct this association will take the long view which has characterised the work of the Geophysical Laboratory at Washington. That work has been carried out on almost ideal lines, with the object of collating the scientific data required for the interpretation of the phenomena afforded by the crystalline rocks in the earth's crust. Although the work was done without practical ends in view, when at the outbreak of war the higher qualities of glass were no longer procurable from

Germany, and it was necessary to undertake their production in America, the data accumulated at the Geophysical Laboratory were so complete that the director was able almost forthwith to take charge of glass manufacture, and satisfactory glasses were soon produced.

A colossal industry is about to arise involving the carbonisation of coal at low temperatures in order that the volatile constituents may be recovered and used as oil fuel. The economic success of this industry will only be secured if retorts and ovens can be provided which will stand the stress of continued use.

It is to be hoped that the programme of the Refractories Research Association will be directed mainly to central problems. No works should be without a scientific assistant, and the larger works will need a regular staff acting under the advice of and in collaboration with the experts attached to the Research Association, these will deal with hand-to-mouth everyday problems; without some such organisation the workers of the Research Institution will not be sufficiently informed as to the problems of the industry to give effective aid in their solution.

The scientific worker, to be successful, must have the gift of imagination, he is therefore more or less of an artist. Many of the glazes and bodies are very beautiful, but the ware is often over-decorated, the designs lack freedom and are too conventional, the colour shades are not always satisfactory. Shape, colour, texture and decoration all contribute to please the eye, and the love of colour is undoubtedly growing. A decorative industry such as that practised by the potter is able to contribute materially to our social advance; let us hope that it may be mindful of this power and regard its exercise as a public duty.

TURBULENT FLUID MOTION AND SKIN FRICTION.*

By Professor T. H. HAVELOCK, F.R.S.

Introduction.—1. It is generally admitted that our knowledge of the laws of skin friction for a solid moving through a fluid is not very satisfactory. This may be ascribed to two main reasons: in the first place the inherent difficulties of the theory of turbulent fluid motion are great even in the simplest cases, and in the second place most of the experimental data which are available have been gathered, not with the primary object of building up a consistent theory, but with more immediately practical aims in view.

Although no general investigation is attempted in the following notes, it is hoped that they may be of interest as a critical discussion of certain aspects of the problem. The work may be summarised briefly as follows:—

(1) An examination of experimental results with a view to defining or estimating the (apparent) velocity of slip of a fluid in turbulent motion past a solid.

(2) The expression of the frictional force per unit area at any point of a plane surface in the form $\kappa \rho v^2$, where v is the relative velocity at the point; determination of the value of κ from experimental results.

(3) The calculation of the total frictional resistance in the case of a plank for which the distribution of velocity is known; remarks on the distribution of velocity for a long plank.

(4) Two numerical calculations to illustrate the assumptions involved in applying a similar method to curved surfaces.

(5) Connection with the law of similarity; the effect of the ratio of breadth to length in the case of planks; remarks on the extension to long planks and high velocities; general problem of ship resistance.

Relative Surface Velocity.—2. When a liquid flows in steady turbulent motion through a pipe it is usual to express the resistance of the wall in terms of the mean velocity over the cross-section, because it can be defined precisely and measured accurately. Further, in any theoretical study of the motion, it seems necessary to assume that the fluid velocity at the wall is zero, there being no slipping of the layer actually in contact with the wall. However, in many cases it is found that the velocity varies little over a large part of the cross-section and is an appreciable fraction of the mean velocity at points very near the wall; this occurs when the turbulent *régime* is well established, either because of high velocities or of large diameter of the pipe. It may be then, for some purposes, a matter of practical convenience to treat the motion as if there were a velocity of slip at the wall. The magnitudes involved may be illustrated by some numerical cases. Taking indirect calculations first, we may quote an instance from Lamb's "Hydrodynamics" (fourth edition, page 654). Assume that the resistance per unit area of the wall of the pipe is given by $\kappa \rho v_0^2$, where ρ is the density and v_0 the mean velocity of the liquid. Also suppose the velocity to be approximately v_0 over the cross-section, except in a thin layer of thickness l in which there is laminar flow. In order to obtain the same resistance per unit area, we must have $\mu v_0/l = \kappa \rho v_0^2$, or $l = \nu/\kappa v_0$, where μ is the viscosity and ν the kinematical viscosity. For water moving with a mean velocity of 300 cm./sec., this gives $l = 0{\cdot}024$ cm.

For the cognate problem of the motion of a solid through a liquid, take an example from Froude's data for planks. The resistance of a 2-ft. plank at 600 ft./min. is given as 0·41 lb. per square foot; the thickness of the equivalent layer for laminar motion giving the same resistance is found from $\mu v/l = 0{\cdot}41$, or $l = 0{\cdot}007$ in., approximately.

But these are indirect estimates, and we turn now to experimental determinations of the velocity. Here the velocity is obtained by means of a Pitot tube, and it is obvious that the nearest point to the wall at which an experimental value can be found depends upon the dimensions of the Pitot tube. For the motion of a plank through water we have Calvert's measurements of frictional wake.* In this case the Pitot tube was one-eighth of an inch in diameter. It was found that the relative velocity at the surface of the plank decreased from full speed at the front end to about half that speed at the aft end of a 28-ft. plank moving at about 400 ft./min. For turbulent flow through pipes, passing over the earlier work of Bazin and others, we may take an example from measurements by Stanton.† The Pitot tube was of rectangular section, the external dimension in the direction of the radius of the pipe being 0·33 mm. With a smooth pipe of 2·465 cm. radius, the velocity at the axis being 1,525 cm./sec., the velocity at 0·025 cm. from the wall is given as 592 cm./sec. Further, the mean velocity is about 0·81 of the velocity at the axis.‡ Hence we may deduce that the (apparent) velocity at the wall is 0·475 of the mean velocity. A similar result is obtained from other cases given in the papers quoted, the value of $V\,d/\nu$ being in the neighbourhood of 50,000.

We shall assume that we can refer to a relative surface velocity which is sufficiently definite for certain purposes, the limitations being indicated by the numerical examples which have been given.

Plane Surfaces.—3. We wish to see if the frictional force per unit area on any plane element of surface can be expressed by $\kappa \rho v^2$, where v is the relative velocity of the fluid and wall at the point, ρ is the density of the fluid, and κ is a non-dimensional coefficient of roughness. One of the earliest attempts to analyse turbulent fluid motion, by Boussinesq, involved a surface friction of this kind, together with a constant effective coefficient of eddy viscosity, or of mechanical viscosity as it was called by Osborne Reynolds. Experimental results on flow through pipes can be fitted more or less by a scheme of this kind, but it is generally recognised now as only an approximate statement. In the first place the mean friction on the walls is not simply proportional to (velocity)^2, but depends also on the diameter; so that the friction on an element of the wall may include a term involving its curvature. Further, the effective eddy viscosity is not found to be constant over the cross-section, though it varies little except near the walls. A similar theory has been applied recently by G. I. Taylor to the turbulent motion of the atmosphere and the skin friction of the wind on the earth's surface.

Rankine, in his method of augmented surface, assumed a skin friction proportional to (velocity)^2; but the working out of the idea involved various assumptions which are no longer regarded as legitimate.

In these notes the scope is much more limited. The method is applied, in the first instance, only to plane surfaces; and, without further theoretical elaboration, some experimental results are examined from this point of view.

To obtain a value of the coefficient κ for smooth surfaces, take first some of the earlier data: Bazin's results for water flowing in open smooth canals of great breadth compared with the depth. These have been expressed in various empirical formulæ. We shall quote one numerical case.§ If R is the skin friction per unit area, V the mean velocity, v_m the velocity at the open surface, and v the (apparent) velocity at the bottom of the canal, we are given—

$$v_m = V(1 + 1{\cdot}81\sqrt{\zeta});\quad v = V(1 - 3{\cdot}62\sqrt{\zeta})$$

where $\zeta = 2R/\rho V^2$. With a mean velocity V = 142·9 cm./sec., and $\zeta = 0{\cdot}0044$; this gives—

$$R = 0{\cdot}0022\rho V^2 = 0{\cdot}0038\rho v^2$$

However, we have a more accurate expression of recent work in Lees' formula for turbulent flow in smooth pipes,‖ namely:—

$$R = \rho V^2\{0{\cdot}0009 + 0{\cdot}0765\,(\nu/V\,d)^{0{\cdot}25}\}^4$$

This formula includes the results of Stanton and Pannell quoted in the previous section. We may, therefore, use for the relation between the velocity v at the wall and the mean velocity V the equation $v = 0{\cdot}475\ V$. Further, if we assume the formula to hold when the diameter d of the pipe is made very large, we deduce an expression for a plane surface in the required form, namely—

$$R = 0{\cdot}004\,\rho v^2$$

We shall use this expression to estimate the frictional resistance of a smooth plane surface, v being the relative velocity at the surface.

4. In order to apply this method it is necessary to know the distribution of velocity over the surface. Unfortunately, there are very few determinations available for this purpose, although, no doubt, others may have been made in recent years. The only direct observations which have been published appear to be those of Calvert, given in his paper on the measurement of wake currents, to which reference has already been made.

A plank, 28 ft. long, and coated with black varnish, was drawn along the surface of water, and measurements were made with (Pitot) tubes projecting beneath the underside of the plank. "The speeds recorded at distances of 1 ft., 7 ft., 14 ft., 21 ft., and 28 ft. from the leading end were respectively 16 per cent., 37 per cent., 45 per cent., 48 per cent., and 50 per cent. of the velocity of the plank, and these proportions appear to be maintained at all speeds between 200 ft. and 400 ft. per minute, the latter being the highest speed that the arrangements would allow."

The relative velocities at these points are thus, respectively, 0·84, 0·63, 0·55, 0·52 and 0·5 of the velocity of the plank. The width of the plank is not stated, and we must assume the effect of the finite width upon the distribution of velocity to be small. Summing up the friction along the plank, supposed of unit width, we have—

$$\text{Total skin friction} = \int_0^{28} 0{\cdot}004\,\rho v^2\,dl$$

From Calvert's observations we may draw a fair curve showing the variation of v^2/V^2 along the plank, where V is the velocity of the plank. It is shown in curve A of Fig. 1. The integral can now be evaluated approximately from the graph. Applying Simpson's rule with intervals of 1 ft., the integral of v^2/V^2 along the plank comes to 10·2. With a velocity V = 400 ft./min., this gives a total resistance of 3·51 lb.

The resistance of the plank was not measured by Calvert. However, we may obtain another estimate from W. Froude's results (*Brit. Assoc. Reports*, 1874). Using Plate II of that report, we can read off from the curves the resistance of a 28-ft. varnished plank at 400 ft./min.; it is 3·51 lb., as nearly as can be estimated. Naturally one need attach no importance to the coincidence, except that with a constant coefficient $\kappa = 0{\cdot}004$, and taking account of the actual distribution of surface velocity the value of the total friction is in agreement with direct measurements in similar cases.

5. It must not be supposed that this method means that the total skin friction is proportional to the square of the velocity V of the body. From the theory of physical dimensions applied to similar bodies we have—

$$R = \rho V^2 f(Vl/\nu).$$

On the present statement, the only difference is that it is the relative surface velocity which is some undetermined function. For instance, in the graph of Fig. 1, if x is the distance from the leading end the graph must satisfy an equation of the form—

$$v^2/V^2 = F(x/l,\ Vl/\nu).$$

After integrating along the plank, we obtain then R in the general functional form given above.

6. Assuming the value 0·004 for κ for smooth planks, we may deduce some information as to the fall of surface velocity, for the mean resistance per unit area divided by $\kappa\rho$ gives the average value of v^2 over the surface.

Taking Zahm's experiments* on varnished planks in air, using a suitable value of ρ and taking the results as they are given in the table for the resistance of planks of various lengths at 10 ft./sec., we obtain the following—

Length ...	2	4	8	12	16
Average v^2/V^2	0·574	0·543	0·516	0·497	0·49

From the similar tables of W. Froude for planks in water at 10 ft./sec., we find—

Length ...	2	8	20	50
Average v^2/V^2	0·529	0·419	0·359	0·316

There is a much quicker fall in water than in air, but, of course, the Vl/ν values do not correspond in the two sets. Froude gives a column which is said to be the resistance per square foot of the last foot of plank. This is, one may suppose, obtained as the difference in resistance of two planks differing in length by 1 ft., and it obviously assumes that the addition of 1 ft. to the rear of a plank does not alter appreciably the distribution of velocity over the rest of the plank. Taking the figures as they stand, we may deduce the average value of v^2 over the last foot of plank for various lengths. They give:—

Length ...	2	8	20	50
Average ...	0·503	0·340	0·309	0·291

The second row being the average value of v^2/V^2 over the last foot. Taking the square root, we may estimate the relative velocity at the end of a 50-ft. plank moving at 10 ft./sec. as about 0·54 of the velocity of the plank, and this estimate will be on the high side. It may be compared with the value 0·475 which we found for the similar ratio in flow through pipes when the steady state has been reached.

Curved Surfaces.—7. If a body is moving through a liquid we may suppose the force on an element $d\,S$ of the surface to be resolved into a normal pressure and a frictional force $R\,d\,S$. The latter will be in a direction opposite to the relative velocity, and, if we suppose it to make an angle θ with the direction of motion of the body, we may define the skin friction as $\int R\,d\,S\cos\theta$, taken over the wetted surface.

For plane surfaces we have shown that there is some justification for taking R equal to $\kappa\rho v^2$, where v is the relative velocity. In the general case one would probably have an additional term involving the curvature of each point. Consider first the case of "two-dimensional" flow, when the longitudinal cross-section of the body is of ship-shape form. Here each element is curved in the line of motion, and if the curvature is small, and we assume $R = \kappa\rho v^2$, the effect of the curvature is to be found in the distribution of velocity. The effect of this kind of curvature has been discussed by Mr. G. S. Baker by estimating the distribution of velocity in stream-line motion. It should be noted that it is not the same as the effect of the shape of midship section, for there the curvature is at right angles to the line of flow. Naturally, in three-dimensional flow both effects are superposed, and cannot be disentangled.

* Paper read before the Institution of Naval Architects, March 26, 1920.

* C. A. Calvert, Trans. I.N.A., vol. xxxiv, page 61, 1893.

† T. E. Stanton, Proc. Royal Society, A, 85, page 366, 1911.

‡ Stanton and Pannell, Phil. Trans., A, 214, page 205, 1914.

§ Data from Mises, *Elem. der Tech. Hydromech.*, teil 1, page 97.

‖ C. H. Lees, Proc. Roy. Soc., A, 91, page 49, 1914.

* A. F. Zahm, *Phil. Mag.*, 8, page 58, 1904.

No experimental determinations* of surface velocity appear to have been published, at least for ship forms in water. The extension from plane to curved surfaces is thus to a large extent speculative. However, as the extension has been made already in other methods, two numerical examples are given here to illustrate the various assumptions.

8. For two-dimensional motion, suppose that the model is 28 ft. long, as for Calvert's plank, with a longitudinal section shown, as to the upper half only, in model C of Fig. 1. This is a form for which Baker and Kent* have calculated the pressure distribution in stream-line motion. From the curves given in that paper we can draw a curve of the distribution of v^2/V^2 in stream-line motion, v being the relative surface velocity and V the velocity of the model. Now, as an arbitrary assumption, suppose that in turbulent flow v^2 diminishes for the model according to the same law as for the 28-ft. plank. That is, we take a reduction factor at each point from the curve A of Fig. 1. We obtain thus the curve C of Fig. 1 as an estimated distribution of relative velocity, or, rather, it shows the values of v^2/V^2 for the model. Also the total skin friction, per unit breadth—

$$= \int R\, d\,S \cos\theta = \int \kappa\, \rho\, v^2\, d\, l$$

taken along the straight axis of the model. Estimating the area under the curve C, and the curved length of Model C, we can calculate the mean resistance per unit area. It appears that the model has a mean resistance per unit area about 11 per cent. greater than that of a plank of the same length.

9. For a three-dimensional case we take similar preliminary data from a paper by Mr. D. W. Taylor† on solid stream forms. We carry out the same process as in the previous section, and it is unnecessary to reproduce the corresponding curves. The only difference arises from the fact that the solid is one of revolution with pointed ends. Consequently the element of area approaches zero at the two ends. If y is the ordinate of the ship form at any point on the axis, we have to graph the values of $y\,v^2$ on the straight axis of symmetry as a base, instead of simply v^2 as in the two-dimensional problem. As far as the numerical approximation has been carried, it appears that the mean resistance per unit area for this model is about equal to, or slightly less than, that of a plank of the same length.

10. The resistance of a small appendage on the surface of a ship must depend chiefly upon the relative surface velocity in its neighbourhood. It is appropriate to refer here to some experiments by Mr. Baker‡ to determine the added resistance due to local roughness of a model. If the rough area were small enough relatively so as not to affect appreciably the flow over the rest of the model, and if the slope of the surface and the direction of flow were known, it might be possible to deduce information about the velocity distribution. However, one cannot analyse in this way the results to which reference has been made.

In regard to skin friction for curved surfaces especially, one may venture to quote and endorse a remark made by Professor Lees§: "It is of prime importance that further measurements should be made on bodies which lend themselves to simple theoretical treatment in order to build up a satisfactory theory."

Law of Similarity for Planks.—11. The law of similarity in its usual form—

$$R = \rho\, V^2\, f\,(V\, l/\nu)$$

applies to bodies which are geometrically similar in form, and are similar as regards scale of roughness. In experiments with planks we may, perhaps, neglect the thickness and suppose the motion to be in two dimensions only; but the planks will not be similar unless the ratio of breadth to length is constant. In other words, the general formula from physical dimensions is—

$$R = \rho\, V^2\, f\,(b/l,\ V\, l/\nu)$$

where the undetermined function depends upon two quantities, the ratios b/l and $V\,l/\nu$.

In most experiments the ratio b/l has not been kept constant, but the planks have been of constant breadth and varying length. Consider, for example, Zahm's results,‖ which he expressed in the empirical formula—

$$R = k\, l^{-0{\cdot}07}\, V^{1{\cdot}85}$$

It is usual, following Lord Rayleigh, to correct this to satisfy the law of similarity and to write—

$$R = \text{const.} \times \rho\, V^2\, (\nu/V\, l)^{0{\cdot}15}$$

It is probably true that the experiments are not sufficient to decide between these two forms. The present point is that, without altering the empirical law as regards l and V, the formula can be made to satisfy the dimensional equation by writing it, for instance, in the form—

$$R = \text{const.} \times \rho\, V^2 \times (l/b)^{0{\cdot}08} \times (\nu/V\, l)^{0{\cdot}15}$$

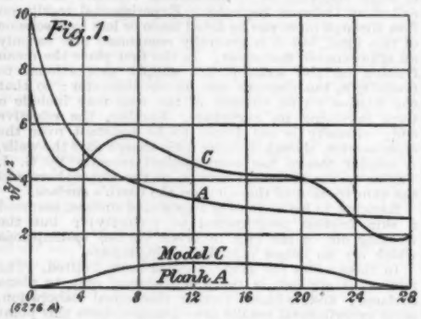
Similar remarks may be applied to Froude's experiments with planks in water. For instance, with planks coated with fine, medium or coarse sand the resistance is proportional to the square of the speed. Hence in these cases the quantity $R/\rho\, V^2$ is a function of the ratio b/l and of the coefficient κ, which may be called the ratio of roughness; but it is not possible to separate the two effects in the results.

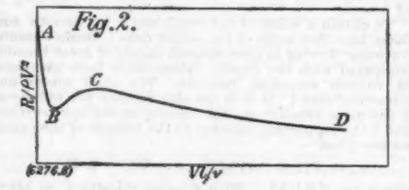
12. Consider the distribution of relative surface velocity from front to rear of a long plank. Neglecting the disturbance of the edges, we may divide the distribution roughly into three stages. Firstly, one in which the velocity falls rather rapidly, then a long stretch in which it is practically constant, and, finally, a relatively short stage in which the influence of the end is appreciable. For a very long plank in which the middle stage predominates, the mean resistance per unit area will approximate to $\kappa\, \rho\, v^2$, where v is the steady value of the surface velocity. On the other hand, for shorter planks a two-term formula may be sufficient, which may possibly be of the type $\rho\, V^2\, \{A + B\,(\nu/V\, l)^n\}$.

Again, if the breadth is taken into account, such a formula would be incomplete. Here, in the extreme case of a long plank of finite breadth, the analogy of steady flow through a pipe is suggested, and the mean resistance should approximate to a two-term formula of the type just given, with the length l replaced by the breadth d. This is the argument which has been worked out by Professor Lees in the paper* already quoted; in that analysis d is taken as the diameter of an equivalent circular cylinder and deduced by a certain method from the dimensions of the plank.

13. On the analogy of the law of similarity for flow in pipes, Mr. Baker† has collected results on planks and models into one diagram, in which $R/\rho\, V^2$ is graphed on a base $V\, l/\nu$. We have seen that certain reservations are necessary in grouping the data from planks in this way; but the general trend of the curves obtained is very suggestive. Fig. 2 shows the main points in a diagrammatic sketch, not drawn to scale, but based on the paper quoted.

The stage A B represents simple viscous fluid motion when R is proportional to V. B C is an unstable condition when the flow may be partly simple and partly turbulent; after C the latter *regime* becomes permanently established. If the resistance R is represented by a single-term formula $f\,V^n$, it is clear that the best single power is V^2 in the neighbourhood of the points B and C. It may be noted that Froude gives V^2 for short, smooth planks of 2 ft. in length, and it may be presumed that the region near C was then under observation. As the length is increased, the best single power decreases to, say, $V^{1{\cdot}85}$ near D, if we take this point to represent the limit of available data. Froude's extension to very long planks is equivalent to extending the curve beyond D, so that it approaches the base-line ultimately. On the other hand, the analogy with the problem of flow through pipes suggests that the curve approximates ultimately to a line at a finite distance above the base-line. In the latter case, the best single power must increase again at some stage and ultimately approach V^2 again. However, it is generally recognised that all that can be said is that any reasonable extension of the curve beyond D must lie within certain limits; that, in fact being the statement made by W. Froude‡ in this respect. We are not able yet to decide between alternative methods.





14. In conclusion, a few remarks may be made on the general problem of ship resistance. It is usual to divide up the total resistance into three parts: frictional, eddy-making, and wave-making resistance. An alternative method is to think of the direct action upon each element of the wetted surface. This action may be resolved into a normal pressure p and a tangential force R at each point. The integrated effect of R gives the total skin friction, while the resultant of the pressure distribution may be called the body or form resistance. In the ship problem it is assumed that the latter corresponds in the main to the wave resistance, together with that due to eddy-making of the more obvious kind. However, in general, the distribution of normal pressure and of tangential force will be interdependent and will each be affected by all the circumstances of the motion. It would be of interest to have some case analysed in this way, with the pressure distribution determined experimentally. This method has been adopted in the corresponding problem in aeronautics, which is simpler in some respects. For an airship envelope, in the form of a surface of revolution, the pressure distribution can be found experimentally. The difference between the resultant and the total resistance then gives the skin friction.* If there were, for the same case, experimental determinations of the distribution of velocity over the envelope, it would be possible to compare the total skin friction with the resultant of a distribution of tangential force $k\, \rho\, v^2$ taken over the surface. Results for submerged bodies in water might be deduced from those in air by the law of similarity; but it would be preferable if direct results could be obtained experimentally, for the distributions of normal pressure and of velocity for simple forms intermediate between the plank and the ordinary type of ship model.

* G. S. Baker and J. L. Kent, Trans. I.N.A., vol. l, Pt. II, page 37, 1913.

† D. W. Taylor, Trans. I.N.A., vol. xxxvi, page 234, 1893.

‡ G. S. Baker, Trans. North-East Coast Inst., vol. xxxii, page 50, 1915.

§ C. H. Lees, Trans. I.N.A., Vol. lviii, page 64, 1916.

‖ Zahm, loc. cit.

* C. H. Lees, loc. cit.

† G. S. Baker, Trans. North-East Coast Inst., loc. cit.

‡ W. Froude, Brit. Assoc. Reports, 1874, page 255.

CATALOGUES.

Liquid Fuel.—An apparatus for finding the ignition temperature of liquid fuels by exploding a small quantity in a heated crucible is described in a catalogue issued by the makers (Mr. Harold Moore is the designer), Messrs. Charles W. Cook, Limited, Bridge-street, Manchester.

Electrical Water Heaters.—Electrically-heated sterilising vessels for medical and dental use, and jugs for heating and boiling water, from 1-pint to 4-pint sizes, are listed in a small catalogue issued by the Cressal Manufacturing Company, Staniforth-street, Birmingham.

Steel Extras.—A booklet stating the price per ton for extra work, such as straightening, sawing, painting, &c., on steel plates and sections, has been received from the Consett Iron Company, Limited, County Durham. The buyer adds these, according to the work required, to the base price for each class of steel.

Milling Cutters.—A catalogue of milling cutters with inserted teeth of high-speed steel has been received from Limit Gauges and Tools, Limited, 3, Arundel-street, Sheffield. Each tooth is held with wedge and screw so that the cutting edges form a spiral. Two diameters and several lengths are made to standard sizes, all parts being obtainable as required.

Scientific Instruments.—Messrs. Adam Hilger, Limited, 75A, Camden-road, N.W. 1, have issued a useful booklet giving brief tabulated particulars of the uses of their scientific instruments indexed under the names of the various products or industries. The instruments include: wave-length spectrometer, photometer, polarimeter, refractometer, saccharimeter, projection comparator, and quartz spectrograph.

Gas Pressure Governors.—A series of regulators and governors for adjusting the pressure of gas supply at meters, gas fires, lamps, branch mains, &c., are described and illustrated in a catalogue issued by the Bryan-Donkin Company, Limited, Chesterfield. The action is automatic and permanent—in the sense that no parts require periodical renewal, and the effect is to convert the variable pressure from the mains into a reduced constant pressure at the point of consumption.

Tamping Machine.—"Tamping" or hammering down the loose earth to fill up a trench after laying a pipe, is generally done by hand labour with a 15-lb. ram. The Americans have, of course, machines for the purpose, for some of which the Hewitt Construction Syndicate, Ltd., 39, Victoria-street, London, S.W. 1, are the agents. It is mounted on four wheels, which bestride the trench, and is equipped with a small oil or petrol engine which drives the machine along and works a tamper of 150 lb. weight at 40 blows per minute.

Hand Trucks.—Mr. H. C. Slingsby, 142, Old-street, London, E.C. 1, sends a catalogue of useful hand trucks, portable elevators, &c. The jack truck lifts a load from the floor and transports it, the loads being laid on wood base boards under which the truck passes when its platform is lowered. In another type the loads are in boxes, with angle irons on the sides, and the truck frame is open, so that it can be wheeled in to enclose the sides of the box, which is lifted on rising rails and wheeled away.

Commercial Vehicles.—A catalogue of 48 pages, issued by Messrs. W. and G. Du Cros, Limited, contains some excellent illustrations of their extensive works at Acton, W. 3, together with specifications and illustrated information about their commercial vehicles of 2 tons and 30-cwt. carrying capacity. The vehicles are supplied as chassis, or complete with the required type of body, of which a considerable variety, made at the company's works, are shown. This firm offers to run and maintain fleets of their vehicles at contract prices.

ENERGY RECOVERY ON THE SCHÖLLENEN ELECTRIC RAILWAY.—Experiments on the recovery of the brake energy, made by Messrs. Brown, Boveri and Co., on the Schöllenen line, which they equipped on the 1,200-volt direct-current system, were described in the "Mitteilungen" of this firm, and are briefly noticed in the *Schweizerische Bauzeitung* of May 8 last. The line is metre-gauge, 3·75 km. long, 2·5 km. of which are rack railway with a maximum gradient of 17·9 per cent. The power is supplied by a transformer station and a battery. The locomotives carry two shunt-motors with six poles, together of 130 h.p., coupled in series. The trial trains were of the full-load capacity, 58 tons. The energy recovered during the downhill run was estimated at 53·8 per cent., measured on the conductor rail, and at 59 per cent., calculated on the power supplied.

* Cf. L. Bairstow, Applied Aerodynamics, page 357.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Name, &c., of the Communicators are given in italics.

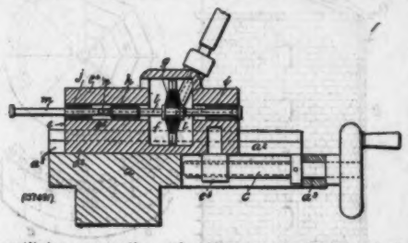
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MACHINE AND OTHER TOOLS. SHAFTING, &c.

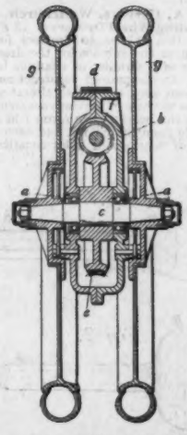
137,491. F. E. Lindsay, Birmingham, and H. C. Armitage, Birmingham. Grinding Machine. (3 *Figs.*) July 23, 1919.—The invention relates to a turbine-driven grinding machine and provides a constructional arrangement in which the casing of the rotor, which also provides bearings for the shaft and the spindle, constitutes a slide mounted for screw traverse upon a saddle which is a fixed member either of the grinding machine itself or for attachment to a lathe or machine; said turbine, its elastic fluid supply, and the bearings for the shaft and the spindle, therefore moving as a one-piece part upon the saddle-like mounting under control of screw traversing devices applied between the slide and the saddle. The saddle *a* has at a^2 a slideway and at a^3 a bearing for a traversing screw *e*, which is stationary except for rotation from a hand wheel. The slideway



constitutes a supporting and guiding way for the base e^2 of a combined casing and slide *e* which is fitted with a screw box e^3, and is traversed by the rotation of the screw *e* which engages the screw-box. The combined casing and slide provides at *f* a cylinder for containing a turbine rotor *g*, and at *h*, *i* and *j* supports for the bearing pieces for the shaft *l* of the rotor and the grinding wheel spindle *m* which practically revolve as one shaft or spindle although the grinding wheel spindle *m* may be detachably connected to the shaft *l* at *n*. The combined casing and slide is formed in two pieces, an upper piece e^4 and a lower piece e^5, carried by the base e^2 joining up on opposed facings passing diametrically through the shaft and spindle similar to an ordinary bearing, the upper piece e^4 being secured to the lower piece e^5 by bolts. (*Accepted January* 21, 1920.)

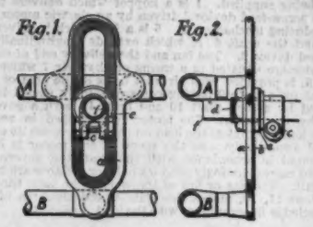
MOTOR ROAD VEHICLES.

137,395. H. W. Alexander, Birmingham. Road Vehicles. (1 *Fig.*) January 28, 1919.—The invention relates to mechanically propelled vehicles of the type in which three road wheels are employed, and has for its object to provide a construction of the third or driving wheel, involving the device known in motor cycles of arranging two similar road wheels close together on the outer ends of a short shaft, these wheels being interchangeable with the non-driving wheels. A pair of bearings *a* in a case carries a short driving shaft *c*. The case is secured to the rear and of a blade spring *d* or hinged arm attached at its opposite end



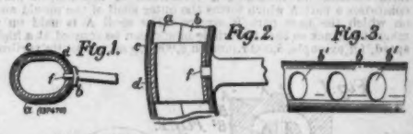
to the main frame. In conjunction with the shaft *c* is any convenient driving mechanism, such as worm wheel *e* gearing with a driving worm *f*. On each opposite outer ends of the shaft is detachably secured a wheel *g* similar in every way to the usual front wheels, all the wheels being thus interchangeable and any of them capable of being replaced by a spare. The space between the rear wheels is comparatively small, being sufficient only to accommodate the spring or arm which carries the gear-case, and the brake rods, so that they form a single rear wheel. (*Sealed.*)

137,385. G. E. Rigby, Manchester. Sidecars. (6 *Figs.*) January 21, 1919.—The invention has reference to adjustable stay attachments for sidecars. The chassis is provided with a grooved, serrated or corrugated member, against which is adjustably bolted or secured a grooved, serrated or corrugated washer or clip carried by the end of the coupling stay. To adjust the stay, it is only necessary to slacken the nut on the bolt, adjust the position of the arm or stay and tighten up the nut again. A slotted plate *a* having serrations *b* formed on one surface



is fixed to the sidecar chassis at A—B. A hollow clip *c* with a threaded shank *d*, and having a serrated washer *e* between it and the plate, is provided so that the clip can be locked in any position along the plate. The coupling stay *f* passes through the hollow clip, and is held in position by tightening the same. (*Sealed.*)

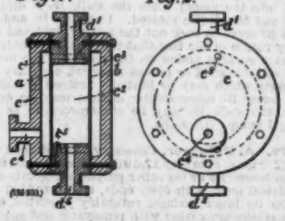
137,479. E. J. Holly, Coventry, and Bluemel Brothers, Limited, Coventry. Steering Wheels. (6 *Figs.*) June 13, 1919.—The invention relates to improvements in steering wheels of automobile road vehicles. According to the invention, the rim comprises two concentric parts *a*, *b*, of ribbon steel, which are substantially U-shaped in cross-section. The edges of these channel-shaped parts are arranged to abut one against the other, and when covered with celluloid *c* this covering holds together the two parts of the rim. To hold together the two parts of the rim while the celluloid is pulled over, the abutting edges of the



two parts of the rim may be spot welded. Further, the two parts may be welded together entirely around one or both of the circumferential joints before the covering of celluloid is applied. The inner metal part of the rim has a row or series of holes *b*1 formed therein so that when the celluloid covering is applied it will shrink or may be pressed into these holes, thus affording a better gripping surface around the inner periphery of the rim. Steel liners *d* are inserted in the rim at the places where the spokes are to be attached. Holes are provided in the rim and the liners to receive tongues *f* provided at the ends of the spokes. (*Sealed.*)

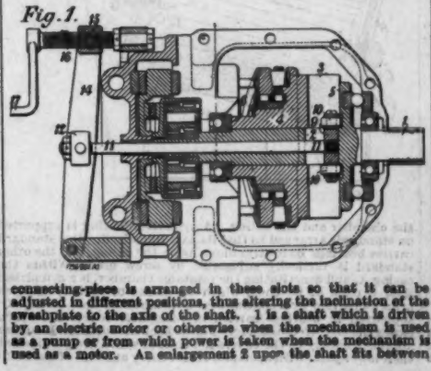
PUMPS.

136,933. W. H. Kane, Larne, and T. McClements, Larne. Fluid Pumps. (2 *Figs.*) January 10, 1919.—This invention relates to membrane or diaphragm pumps for pumping or compressing fluids, and of the kind in which the pulsations of the membranes or diaphragm plates are produced by periodic variation in fluid pressure or by alternating suction and pressure. The present invention contemplates a pump of the kind stated,

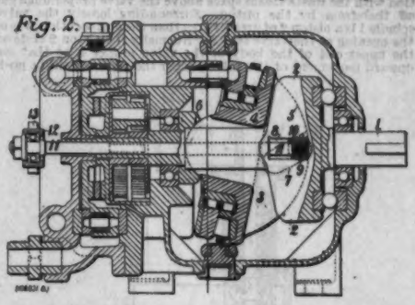


having two diaphragm plates *a*, *b* situated at some distance apart within a casing *c* in such a manner as to form three compartments c^1, c^2, c^3, of which, under one arrangement, the compartment c^3 between the diaphragm plates is provided with inlet and outlet ports d^1, d^2, respectively, and constitutes the pump chamber, whilst the two outer compartments c^1, c^2 are placed by the port c^4 in communication with the actuating fluid. (*Sealed.*)

136,931. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-on-Tyne, H. W. Lee, Newcastle-on-Tyne, and W. A. Jeffrey, Newcastle-on-Tyne. Swash-plate Mechanism. (2 *Figs.*) January 9, 1919.—According to this invention, an inclined slot is cut in a cheek on the swash-plate and a slot is cut in the shaft parallel to its axis, while a



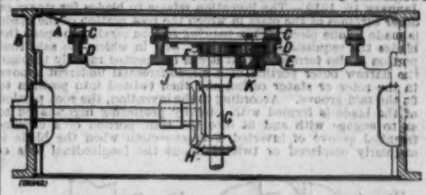
connecting-piece is arranged in these slots so that it can be adjusted in different positions, thus altering the inclination of the swashplate to the axis of the shaft. 1 is a shaft which is driven by an electric motor or otherwise when the mechanism is used as a pump or from which power is taken when the mechanism is used as a motor. An enlargement 2 upon the shaft fits between cheeks 3 of the swashplate 4, so that the shaft and swashplate rotate together. The swashplate 4 is guided by semi-cylindrical surfaces 5 on the shaft, and by semi-cylindrical surfaces 6 keyed to the shaft. In the cheeks 3 are cut inclined slots 7, while in the shaft is cut a slot 8 parallel to the axis of the shaft. 9 is a block carrying rollers 10. The block is capable of movement in the slot 8, while the rollers are capable of movement in the slots 7. Connected to the block is a rod 11 which passes through a hole bored in the shaft and out through the casing of the



mechanism, and carries a collar 12 within which it can rotate freely. Pins 13 on this collar are engaged by a pair of levers 14 pivoted at one end to the casing and at the other end to a nut 15, meshing with a screw thread 16, provided with a handle 17. By turning the handle the nut will be traversed along the screw and consequently the rod 11, can be pushed in or out to move the block 9 away from or towards the centre about which the swashplate oscillates, thus altering the angle of the swashplate. (*Sealed.*)

PRINTING AND ALLIED MACHINERY.

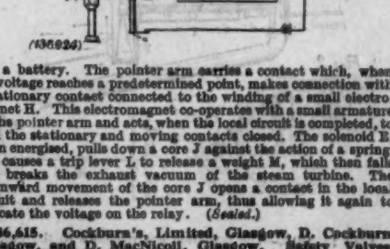
136,928. Payne and Sons (Otley), Limited, Otley, and W. A. Payne, Otley. Reciprocating Bed-Printing Machines. (2 *Figs.*) January 7, 1919.—The present invention has reference to printing presses in which the type bed is reciprocated by means of a double rack, the opposite sides of which mesh alternately with a constantly-rotating pinion, which is thus enabled to move the bed backwards and forwards. The rack is usually kept in gear with the pinion by means of a track located on the underside of the bed and movable with the rack transversely at the ends of the reciprocatory movements of the bed, this track engaging a bowl on a fixed axis. According to this invention, the moving track is done away with and there is employed a fixed endless double-sided track or slot in which runs a bowl depending from the rack or rack-holder, so that the rack is kept continually



in mesh with the driving pinion. A is the bed which is capable of reciprocatory movement in the frame B, being supported by bowls C running on rails D; mounted beneath the bed is a rack E, which is capable of transverse movement relatively to the bed and which meshes with the driving pinion F fast on a spindle G driven by bevel gear H from the main shaft I. J is an endless double-sided track or slot secured to the fixed frame B; in this track moves a bowl K, which is pivoted to the rack E. As the pinion F rotates, say, clockwise, the rack and bed move towards the right, the bowl travelling with the rack in the track until it comes to the curved portion of the right-hand end of the track, when it begins to traverse the rack beneath the bed, holding the rack in gear with the pinion until the bowl reaches the straight portion of the track, when the track and bed are moved, to the left. (*Sealed.*)

STEAM ENGINES, PRODUCERS, HOLDERS, &c.

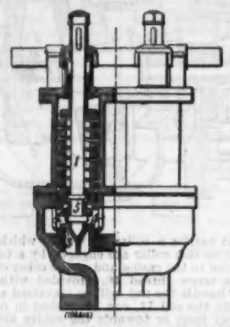
136,924. E. H. Beckett, London, and F. H. Nalder, London. Controlling Steam Turbines. (2 *Figs.*) January 4, 1919.—According to the present invention, electromagnetic apparatus is employed acting to control the exhaust vacuum of the turbine, such electromagnetic apparatus being energised by a current proportional to the speed of the turbine. A are the mains supplied from an alternator driven from a steam turbine (not shown). Across the mains A is a transformer C having its secondary winding connected to a voltmeter relay which has some part of its moving system, for instance, the pointer arm connected in a local circuit, including a solenoid E



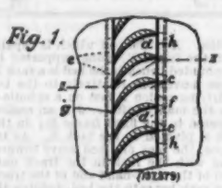
and a battery. The pointer arm carries a contact which, when the voltage reaches a predetermined point, makes connection with a stationary contact connected to the winding of a small electro-magnet H. This electromagnet co-operates with a small armature on the pointer arm and acts, when the local circuit is completed, to hold the stationary and moving contacts closed. The solenoid E, when energised, pulls down a core J against the action of a spring, and causes a trip lever L to release a weight M, which then falls and breaks the exhaust vacuum of the steam turbine. The downward movement of the core J opens a contact in the local circuit and releases the pointer arm, thus allowing it again to indicate the voltage on the relay. (*Sealed.*)

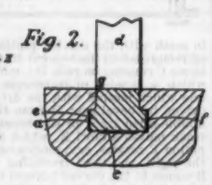
136,615. Cockburn's, Limited, Glasgow, D. Cockburn, Glasgow, and D. MacNicoll, Glasgow. Safety Valves. (1 *Fig.*) December 16, 1918.—The invention relates to a safety

valve of the type fitted with a piston positioned above the valve proper and movable relatively to the valve spindle under the influence of fluid pressure to engage a collar on the spindle and effect increased lift of the valve proper. According to the invention, the arrangement is such that the piston normally rests on the valve proper, and is positively lifted on the rise of the valve proper so as to occupy a cylindrical chamber, which is normally unoccupied by the piston, and which is in communication with the waste steam space above the valve proper until cut off therefrom by the piston. Surrounding loosely the valve spindle 1 is a piston 2 of greater area than the cross-section area of the opening at the valve seat 3. Normally the piston 2 rests on the upper end of the body of the valve proper 4, so that on upward movement of the valve proper the piston 2 will be positively lifted. On the valve spindle 1 above the piston is a collar 5. 6 is a cylindrical wall forming the lateral boundary of a cylindrical chamber above the valve seat 3, which chamber, when the valve proper 4 is in engagement with the valve seat, is in communication with the waste steam space above the valve proper, being so spaced from the valve seat 3 as to be then unoccupied by the piston 2, but which is cut off from such waste steam space by the piston 2 when the piston rises with the valve proper; the piston being a fit within the cylindrical chamber. When the valve proper 4 rises from its seat, the piston 2 also rises and, entering the cylindrical chamber, is forced upwardly against the collar 5 by the pressure of steam on the underside of the piston 2, whereby there may be obtained increased lift of the valve proper. (*Sealed.*)

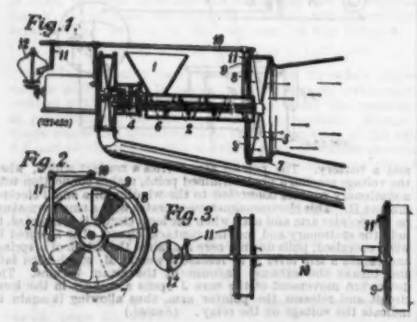


137,379. Vickers, Limited, Westminster, London, Sir J. McKechnie, K.B.E., Barrow-in-Furness, and G. W. Johnson, Barrow-in-Furnace. Turbine Blades. (4 *Figs.*) January 16, 1919.—The invention relates to blades for steam or other turbines of the class in which the root portion of the blade is made in one piece with a packing section serving to space the blades the requisite distance apart, and in which the said root portion is also formed so that it can be inserted radially through the narrow outer portion of a circumferential undercut groove in the rotor or stator casing and then twisted into position to fit the said groove. According to the invention, the root portion of the blade is formed with laterally projecting lugs shaped so as to engage with and fit into the wide portion of a circumferential groove of inverted T cross-section when the blade is angularly displaced or twisted about the longitudinal axis of the blade. *a* is the groove in the turbine rotor or stator drum, which groove is of inverted T cross-section. *c* is the root portion of the blade *d* formed with laterally projecting lugs *e*, *f*, adapted to engage with the undercut or wide portion of the groove *a* when the blade *d* is twisted into position as stated above. When the blade is in this position, portions of the packing or spacing section forming part of the root *c* bear against the side walls of the narrow portion or neck of the groove *a* as seen at *g*, *h*. When all the blades are in their final position, they are positively prevented from participating in any twisting displacement. In the complete blading operation each of the blades is in position with the exception of the last one which requires for its insertion into place a locally widened groove, which is subsequently filled in by a locking piece secured in any appropriate manner. (*Accepted January 21, 1920.*)





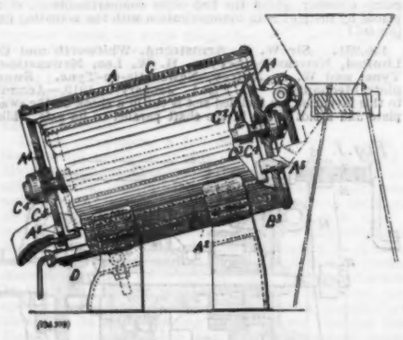
137,480. J. S. Atkinson, Westminster, London, and the Powered Fuel Plant Company, Limited, Westminster, London. Combustion of Powdered Fuel. (5 *Figs.*) April 17, 1919.—The invention has reference to the propulsion of powdered fuel into the combustion chamber by means of a fan and in intimate admixture with air, and the invention has for its object the provision of means whereby the supply of air may be regulated in accordance with the load on the plant and the amount of fuel being supplied. The admission of air to the fan is controlled by governor-controlled means, such as a hit-and-miss device, in accordance with the load on the plant and the amount of fuel being supplied. 1 is a hopper which delivers powdered fuel to a screw-feed device 2 driven by an electric motor through speed-reducing mechanism 4. 5 is a fan which is driven by the motor and the shaft 6 of which extends longitudinally of the screw-feed device 2. The fan and the delivery end of the screw-feed device are situated in a casing or chamber 7 which, behind the fan 5, is provided with air inlet holes 8, the area of which is regulated by a plate 9 having correspondingly placed holes and connected by a rock shaft 10 and links 11 with a governor 12 driven by the motor. The motor is controlled in accordance with the load, so that as the load on the plant varies its operation is varied accordingly. As the speed of the motor is increased or decreased in accordance with the load, the governor 12 is influenced correspondingly, and its balls or weights are caused to rise or fall. The rise or fall of the weights or balls through the connections 11, 10, moves the plate 9 and the area of the air inlets is varied in accordance with the load. (*Sealed.*)



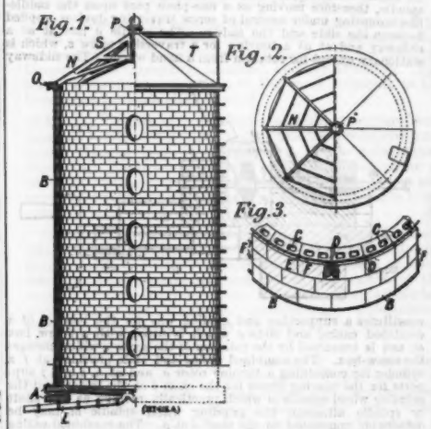
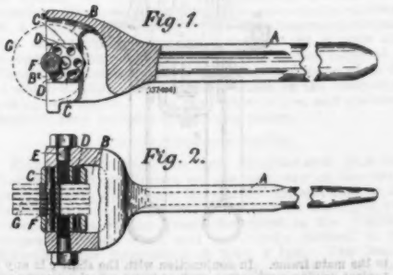
MISCELLANEOUS.

136,862. Vickers, Limited, Westminster, London, and N. E. Dufty, Tulse Hill. Manufacture of Moulded Bodies. (3 *Figs.*) September 18, 1918.—This invention relates to improved devices for moulding objects made from any material, including formaldehyde condensation products and also earthenware. The invention relates to that type of moulding device which is rotated for the purpose of solidifying by centrifugal force the material to be moulded. According to one feature of this invention, a device of the type referred to is adapted to be rotated at high speed about the axis of the article to be moulded, and is provided with passages which produce a radial sucking action when the device is rotated tending to remove liquid and gas from the material being moulded. The device, which is of a form suitable for moulding a cylindrical or cup-shaped part, comprises a part A which forms the outer shell of the mould and on which the base part B screws. The shell A is held on a magnetic chuck so that the whole mould can be rotated at a high speed, for example, 5,000 r.p.m. to 8,000 r.p.m., about its vertical axis, the spigot A^1 being provided to centre the mould on the chuck. The shell A may be split into a number of separable parts to facilitate the removal of the moulded article. The base part B is provided with a stem B^1, which forms the core of the mould. Up the centre of the stem or core B^1 is formed the inlet channel B^2 for admitting the material to be moulded, which material is in liquid form, distributing channels B^3 leading from the channel B^2 being provided. At the bottom of the channel B^2 is fixed an archimedean screw B^4, which serves to force the liquid material into the mould when the stalk B^5 is dipped into the material and the device rotated. Channels B^6 and their feeder channels B^7 serve to suck out the mixing fluid and air from the mould by reason of the fact that they act as a centrifugal pump and exert a sucking action on the mould. The mould may be made of suitable solid or porous material, and may be provided with jackets which may be heated. Instead of using an archimedean screw B^4 other similar devices may be employed, for example, the stalk B^5 may be constructed so as to act as a centrifugal pump. (*Sealed.*)

136,379. A. P. Digger, Coventry. Appliance for Drying Sand. (2 *Figs.*) February 17, 1919.—The sand-drying apparatus for use in foundries or for other purposes, consists of a chamber of cylindrical form with open ends, and provided with ribs or baffles on its inner surface, rotatably mounted and enclosed within a stationary casing with removable end-covers, in which latter are situated the entry and exit apertures for the sand, and through which end-covers extends a driving axle carrying the rotatable chamber. The heating means, such as gas burners or electric coils, are situated in the lower part of the space between the chamber and the casing. A cylindrical casing is supported on standards arranged so that its axis is inclined. One standard carries bearings B^2 for trunnions A^3 on the casing, and the other standard is vertically adjustable by screw gear. Within the casing A, and constituting the rotatable chamber, is a cylindrical shell C open at its ends, which by means of radially-disposed arms C^2 carried by a central boss C^3 is mounted upon an axle C^4 supported in bearings carried in removable covers A^4, which closes the end of the casing. The ends of the rotatable chamber approach closely to the covers A^4, both of which are provided at their lower parts with apertures A^5 for entry and exit of the sand. The diameter of the rotatable chamber C is such as to provide an annular space between it and the casing A, and in the lower part of this space are situated electrical heating coils, or the fuel burners D to heat the underside of the chamber C. The interior of the casing A may be lined with material to prevent loss of heat. Within the rotatable chamber are longitudinally disposed ribs C^5 or baffles which ensure the sand being carried round to the upper part of the chamber to fall from there to its lower part and be continually agitated in the progress. The moist sand is delivered to the upper end of the heating chamber by a hopper F connected by a shoot F^2 with the aperture A^6 in the adjacent end-cover A^4. A shut-off slide F^4, allows the flow of sand to be regulated or entirely cut off. The aperture A^5 in the lower end-cover A^4 of the casing is provided with a shoot G to discharge the sand. (*Sealed.*)



137,415. P. Yorke, London, and The Standard Building Construction Company, Limited, London. Silos. (5 *Figs.*) February 27, 1919.—The invention relates to silos for the preservation of fodder for animals by the well-known process of ensilage. A is the foundation, on which there are built concentric annular layers of concrete blocks B, B, each of which has in its interior two vertical holes C, C, and at each of its ends a vertical groove D of semicircular cross-section. The vertical holes C, C, of the several layers are arranged to register with each other so as to form ventilating passages which extend from suitable points in the inner surface of the walling to the top of the silo, where they may open into the space beneath the roof. The end grooves D, D, when the blocks are in place, register with each other and serve to receive cement E, so as to form a cement joint between each pair of blocks. Moreover, at the radius of the cement joggles E, E, there is arranged in a groove in the upper surface of the block a steel reinforcing rod F, in the form of a continuous ring, this rod being embedded in cement at the same time as the cement joggles E, E, are formed between the blocks. The bottom of the silo is provided with a floor sloping towards a suitable trapped drain L, and the outer sides of the blocks which lie below the ground lever are protected by a coating of asphalt or other suitable material, which is extended to form a damp-course. The roof of the silo is formed by a series of radially-arranged roof principals N, N, which are formed of reinforced concrete. These rest at the bottom against a ring O of reinforced concrete. The upper ends of the roof principals abut against a wedge-shaped finale P. The roof principals N, N, have a series of holes in which are threaded wires that support concrete slabs, plastic concrete, united with waterproof cement in any suitable manner, as indicated at S, Fig. 1. One section of the roof may be formed by a dormer T constructed of reinforced concrete and provided with a door or the like in any suitable manner. (*Sealed.*)



137,404. Sir A. Herbert, Whitchurch, and J. Dobson, Sheffield. Grinding Wheel Dressers. (3 *Figs.*) February 12, 1919.—The invention relates to dressers for grinding wheels of the kind in which the spindle for the dressing discs may be fitted in any pair of a number of bearings in carriers separate from the holder. In the present construction the bearings may be changed without any structural alteration to the carriers, which has not been the case in previous constructions. According to this invention, the bearings are formed in a pair of rotatable carriers detachable from the holder, and each carrier is provided with a plurality of bearings or holes constituting the bearings which are arranged in a ring around the axis of rotation of the carriers, so that the life of each carrier is considerable. The holder A is formed with jaws B and the opposed faces of the jaws are slotted at B^2 to receive the carriers C, which lie against the jaws. Each carrier is polygonal, having as many sides as there are bearing holes D, and the flat sides C^2 engage the sides of the slots B^2 in the jaws. The carriers are secured to the jaws by screws E screwing into holes in the centre of the carriers, and the carriers can be fitted in the holder in as many angular positions as there are sides. The spindle F is offset from the screws E, and therefore the discs G project considerably from the holder. (*Sealed.*)